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METEOROLOGY OF THE MOON.

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The fundamental fact on which is based the study of the meteorology of Mars is the melting of its polar caps. The moon has no well defined polar caps, although its northern and southern limbs are appreciably brighter than either of its equatorial ones. There are however scattered over the whole of its surface numerous minute white spots more or less sharply defined and it is to some of these that we shall now direct our attention.

The object with which we will begin our studies is the well known mountain Pico. This mountain is situated in longitude 9°, latitude +45°. Its vernal equinox therefore occurs at colongitude 9°, its summer solstice at 99°, or just after full moon, and its autumnal equinox at 189°. Its altitude is 8000 feet or 2500 metres, and its length east and west 10″, 11 miles, or 18 kilometres. No craters whatever have been detected upon it, but if any existed that were less than 0″.1, 500 feet or 150 metres in diameter they would probably have escaped notice. It is not strictly a mountain in the geological sense of the word, but rather a spiracle or pinnacle, such as occur in some of our volcanic regions, Mem. Amer. Acad., 13 Plates 19 and 20. Perhaps the best idea of its appearance as compared with terrestrial mountains may be obtained from Figure 7, See Plate VIII. The figures on this plate are all oriented with north at the top. This is unusual, but is better adapted to the illustration of the present paper than the usual orientation would be.

It is perhaps unnecessary to state that every line and shading shown in the drawing actually exists on the moon. It has not been touched up in any way to give it a resemblance to a terrestrial peak, but the mountain is represented exactly as it appears as seen through the telescope. Independent drawings made a little earlier and later in the lunation show practically every detail shown in the present sketch.

It was drawn just as the sun was setting upon it, and consequently its western side is invisible. It must be remembered that on the moon the terms east and west are given the reverse meaning that they have on the earth and Mars. What we call east on the planets is called west on the moon, and *vice versa*.

Although this view gives the effect of having been sketched from but a slight elevation above the plain on which the mountain is situated, yet the angular elevation of the line of sight, as is shown by the latitude above given, is 45°. Pico is therefore not quite as steep as it appears in the sketch, the eastern slope lying at an angle of approximately 35°, and the western, shown in Figure 1, of about 42°. It is also noticeable that the snow is found on the ridges, and not in the ravines, as in the case of our own large accumulations of ice. This is even more conspicuous in the case of Teneriffe shortly before the time of full moon, where the ridges and ravines are much more marked than they are on Pico.

As to the origin of the formation, it is pretty clearly a piece of the original lunar crust which was surrounded but not overwhelmed by the great fissure eruption causing the Mare Imbrium. If of less specific gravity than the black lava of the eruption, it might even have floated away from its original location and possibly turned over like an iceberg. In such a case there would be no reason to expect to find craterlets on its present summits. Nevertheless, the fact that the snow is found mainly upon the ridges leads us to believe that cracks exist along their crest lines. From these cracks water vapor escapes, and on account of the deficiency of the lunar atmosphere is immediately redeposited as snow. This peculiarity is shared by other lunar mountains as we have just seen, and would lead us therefore to believe that Pico still occupies its original position, and has withstood the devastating flood by which it was surrounded.

In the accompanying plate the first seven drawings represent Pico. Under each is given the date, the colongitude, the magnification employed, and the quality of the seeing on a scale of 12. Located upon the mountain are eight prominent white patches which we shall designate as snow. They have been lettered as indicated in the third figure. Although located in longitude 9°, yet so high does it rise above the surrounding plain, that the sun first touches its summit shortly before colongitude 7°. At 7°.1 not only is spot *a* located upon the very summit of the mountain, dazzlingly brilliant; but the more elevated portions *b* and *c* can also be seen. By 9° *c* has rapidly increased in size, but *a* and *b* are practically unaltered.

At colongitude 19°.6, Figure 1, *c* has about double its size, and other portions of the mountain are now visible, together with its long shadow

stretching away towards the east. Spot *a* is of brightness 10 and *b* and *c* 9, or a very ittle fainter.

By colongitude 32°.9, Figure 2, nearly the whole of the south-eastern side of the mountain has become visible, but none of the snow patches located upon it in some of the later figures have yet formed. Directly below the eastern summit however a crescent shaped area has appeared which was described and painted as distinctly green, greener than the *mare*, which itself at this age of the moon is slightly greenish. Beneath the crescent a large area appears which is still in shadow, and close at hand to the west is another one, while spot *a* has increased in size, and the whole of it is now illuminated; spot *c* on the other hand has diminished, probably through melting. The next night at colongitude 44°.0 much trouble was experienced from passing clouds, but it was clear that *a* was unchanged, while *c* had increased in size, appearing as in Figure 1. The whole of the south-eastern face was still dark, with the exception of a small white spot which had appeared half way up the slope, at the top of what was later designated as *d*. An observation made on September 21, 1912 at 40°.7 records that there was no snow at all at that time on the eastern face of Pico.

In Figure 3, colongitude 55°.9, the whole eastern face is resplendant with freshly formed snow, yet not quite so brilliant as at the higher levels, perhaps because on the lower and steeper slopes small projections of rock more frequently interrupt the bright surface. Spot *c* has greatly increased in size, *a* has diminished by melting away from the eastern end of the ridge, while new spots have formed at *d*, *d'*, *e*, *f*, and *g*. Spots *d*, *d'*, *e*, and the western ends of *b* and *c* were distinctly greenish, and this appearance frequently occurs when the formation of snow is very light, due perhaps to small scattered patches. The effect may be subjective, although it does not look as if it were. Spots *f* and *g* were the brightest of the south-eastern patches, a supremacy which the southern one, *g*, soon loses under the influence of the direct summer sun.

The next night, 68°.2, spot *a* had returned to the eastern end of the ridge, increasing slightly in size at the same time; *b* and *c* had diminished, the latter notably; indeed it varies more in size and shape than any other spot on the mountain. This is quite natural since it lies on a wide comparatively level region, with a southern exposure. In fact it had broken into several smaller pieces which are shown in the drawing made on the following night. Changes were suspected between drawings made early and late in the evening. Spot *e* had increased in size but not in brightness. Spots *d* and *d'* had now united, but *d* was distinctly the brighter of the two.

An interesting phenomenon is exhibited at this colongitude, when spots *a* and *d* begin apparently to steam. In a few hours thick clouds of vapor are thrown off, especially from *d*, so that its outlines become very hazy, and quite different from its earlier and later appearance, and from the other spots about it. Its color becomes decidedly bluish, and the fog or mist in a thin transparent stream is swept off across the *mare* to the south, as indicated in Figure 9. The action becomes less

FIG. 9.
Sept. 24, 1912
78°.8 330 10

violent about colongitude 90°, and by 95° has ceased altogether, as a usual thing, although it was observed on one occasion at the base of *d* as a very faint haze as late as 115°. All the spots have occasionally been recorded as slightly hazy at about this time, but none of the others are at all comparable in this respect to *d*. At colongitude 76°.8 the ridges of Teneriffe have been recorded as steaming from end to end. In the meantime neighbouring bright spots were perfectly sharp and distinct. This steaming might be either a case of melting snow or of volcanic activity, the steam condensing into ice crystals and falling as snow. The writer rather favors the latter view, since the other spots do not exhibit it.

Knowing what to expect at this colongitude, *d* was carefully examined early in the evening at 68°.8, and was recorded as "not notably hazy." At 70°.0 it was recorded "*d* and *d'* rather indistinct, *d* the most so, but not as hazy as they have been seen". At 70°.1 "*d* is now clearly hazy." The next night at 81°.9 "All spots are more or less hazy, but *dd'* especially so." Where the steam flows away at the base of the mountain across the *mare* it is extremely faint.

The following are all the other records that have been made pertaining to the haziness of *d*.

September 23, 1912. 64°.8. No steam from Piton or Pico *B*, but Pico sending a thin streak south from *d*.

February 18, 1913. 65°.4. The "snow storm" has begun on *a* and *d*, but *d* is very faint, greenish, and quite separate from *d'*.

December 21, 1912. 69°.3. The snow storm has begun. *d*, *e*, *f*, and *g* are all hazy and bluish, but *d* much the most so, while *a*, *b*, and *c* are very sharp.

March 20, 1913. 71°.4. Pico *d* and *d'* enveloped in cloud.

August 25, 1912. 72°.0. Pico is perhaps beginning to steam.

November 22, 1912. 74°.4. Pico. Snow storm on the northeast peak (*d*) well developed, bluer than the other peaks. The northern peak (*a*) shows the same to a less marked degree. 74°.6. Snow storm wonderfully well developed.

September 24, 1912. 78°.5. Pico *d* is very foggy as compared to *b*, *c*, *e*, *f*, and *g*. Spot *a* is a little foggy, but nothing like so markedly so as *d*. The contrast between *d* and *f* especially is very striking.

December 22, 1912. 81°.8. Pico. The snow storm on *d* still continues, but it is not so hazy tonight.

August 26, 1912. 84°.1. As compared with last night, 72°.0, *d* has grown larger and more fuzzy.

March 21, 1913. 84°.4. Pico *d* is still a trifle brighter than *f*. It is a little more hazy.

January 21, 1913. 86°.0. Pico, storm at *a*, *b*, *c*, *d*, and *d'*.

September 25, 1912. 90°.4. All the spots except *c*, *e*, and *f* are as hazy as *a*; *d* no more so than the others.

December 23, 1912. 94°.3. Pico *d* is now much the brightest. The snow storm is over.

January 22, 1913. 97°.8. Pico *a* and *d* have increased in size and are still a trifle hazy.

November 27, 1912. 99°.5. Pico *d*. Cannot be sure if the haziness has disappeared. 100°.5. Think the snow storm still continues, but has diminished.

September 26, 1912. 103°.3. All the spots are sharp.

August 28, 1912. 109°.5. A very faint haze extending south from *d*.

November 25, 1912. 113°.2. The snow storm has ceased.

September 27, 1912. 115°.2. The base of *d* and *d'* is perhaps a little hazy, but all the rest of the mountains seem clear, including Pico *a*.

September 28, 1912. 126°.7. All the bright areas on all the mountains seem to be sharp.

The "snow storm" referred to in several of these extracts is a possible explanation of the phenomenon observed, since, as it progresses, *d* gradually becomes brighter than before and sometimes larger. At the same time *d* is clearly shown, with sharp borders, one day before the general haziness usually appears. Moreover some of the other spots, notably *f*, are equally bright with *d*, and only on the rarest occasions appear hazy.

In the fourth figure, 81°.8, the notable changes from the previous one are the coalescing of spots *d* and *d'*, and the breaking up of *c* into small pieces. Spot *e* has broadened and grown brighter, gradually advancing towards the east. No marked change occurs for the next three days, save that the haze on the *mare* at the foot of *d* becomes more distinct. At the end of that time at colongitude 115°.1 spots *a*, *b*, and *c*, are found sometimes to have shifted their position angles so as to lie nearly northwest and southeast. Spot *a* does this by gradually working its way around the northern corner of the mountain. Spots *b* and *c* change more suddenly. On January 31, 1915, at colongitude 106°.7 spot *b* had disappeared.

In Figure 5, 126°.7, an entirely new though faint spot, which we have called *h*, has formed midway between *a* and *f*. This drawing is the only one which has been secured of it. The previous night a drawing was made showing all the other eight areas, but nothing in the place of *h*. The following night *c* had disappeared and the brightness of all the other areas is recorded, but no mention is made of it. Moreover neither the drawings and estimates of brightness made December 25, 1912, 118°.7, and December 26, 1912, 130°.4, nor Figure 6 made January 31, 1915, 132°.2, show any trace of it, although it was looked for carefully on the latter night.

An examination of Figure 6, 132°.2, shows clearly the location of two ridges situated on the western flank of the mountain, whose shape explains in part the forms of spots *b* and *c*. By colongitude 147°.9 the sun has set on the western slope and in that drawing and at 159°.3 the appearance is very similar to that at 183°.6 when Figure 7 was drawn. The chief difference is that in the earlier drawings the spots *d*, *d'*, *e* and *f* all reached down to the level of the *mare*, while in the later one at 183°.6 *d'*, *e* and *f* have already begun to melt and disappear at their bases. This does not always happen, however, for on October 3, as late as 189°.5, *d*, *d'*, and *e* are all shown as reaching down to the level of the *mare*, the terminator at this time passing through the base of the mountain.

As the result of observations made on 29 dates, extending over two years and a half, and lying between colongitudes 7°.1 and 189°.5, we may summarize our results and state that spots *a*, *b*, and *c* first became visible at sunrise with full brilliancy 10, and that *d*, *d'*, *e*, *f* and *g* appear at 56° with brilliancies 6 to 8, some two days after the sun first reaches the eastern side of the mountain. At about 80° these latter points brighten, but with the exception of *d* never reach full brightness. Just before this *d* becomes very hazy for a couple of days and *a* less so. At 100° *a*, *b*, and *c* begin to fade, and at 130° the two last disappear, the sun setting upon that part of the mountain about

two days later. At 130° *g* begins to fade, but all the spots save *b* and *c* are visible until near sunset. Spot *h* appeared once for a short time at 127°. Spot *c* is the one which varies most in size and shape during the lunation, and also from one lunation to another. Its variations are most marked between colongitudes 45° and 70°.

Other mountains in this immediate vicinity carry spots of variable size, and also present other features of interest. Just to the south of Pico, in longitude 9°, latitude +43°, lies the long elevated ridge Pico *B*, not to be confounded with the crater Pico *B*, located beyond the Teneriffe Mountains. *B* rises at the western end to a height of 5000 feet above the surrounding plain, and is about 10 miles in length. On account of its isolated position it is visible in nearly its entire length at colongitude 7°.1, the western end and middle peak being brilliant with snow. These spots are very persistent, and by 56°.2 are more conspicuous than anything on Pico itself. The northeastern side of the ridge is now beginning to show, and by 69°.8 is clearly seen. On July 23, 1912, 26°.6, it is recorded "the upper slopes of Pico and nearly the whole of *B* are as bright as the brightest summits of the Alps." This certainly was not the case on January 24 or 25, 1915, 19°.8, 33°.6, when the two spots were but little larger than indicated in Figure 8. On September 23, 1912, 64°.4, Figure 8, a small but easily seen white spot, one mile from top to bottom by one quarter of a mile in width, lay upon the southern slope of the mountain half-way between the two larger spots. It was visible also September 24 and 25, 78°.5, 90°.4, but the next night, 103°.3, had disappeared. It was also visible August 26, 1912, 84°.3, but the next night had vanished. It did not appear this year at all, but on January 28, 69°.8, a faint line of snow lay along the crest of the mountain connecting the two large spots, thus lying at right angles to that seen in 1912. The next night it had already begun to melt at both ends, thus severing its connection with the spots.

A curious feature which shows well on this mountain appears at or a little earlier than 69°.8. This is a row of almost contiguous bright dots which make their appearance along the eastern portion of the southern base (see Figure 8,) just where it rises from the plain. They are never very bright, seldom exceeding 7, but they gradually extend further towards the east. Two nights later another row extending the whole length of the northern base is also seen. Similar rows line both sides of Schroeter's Valley near Aristarchus, as also the rills of Hyginus and Ariadæus, although the last is rather faint. They look like columns of steam or cloud, and it is possible such may really be the case, as these are just the locations where hot springs occur in the case of the earth. If they are due to springs of water they need not necessarily be hot, since on account of the low atmospheric pressure, water would

boil at the freezing point, 32°, on the moon. Whatever their explanation, they form it is believed a hitherto undescribed feature of the lunar landscape.

On September 25, 1912, at 90°.4, Pico *B* was steaming vigorously at its eastern end, the steam drifting off across the *mare* towards the north. This is the only record we have of steam clouds from this mountain. On February 2, 1915, 132°.4, the western spot had vanished, while that at the middle was faint. September 29, 1912, at 139°.9, it too had gone. Somewhat earlier, spots had appeared on the north-eastern face, and one near the middle was quite conspicuous, August 31, 1912, at 148°.1. Nothing of the sort was seen February 3, 1915, at 146°.6. September 1, 1912, at 166°.2 a second smaller spot appeared just west of the other. The southwestern slope of the mountain was still visible, but the next night was enveloped in shadow, and another small spot had appeared on the northeastern side. This was our latest observation of it.

While these observations are all easy enough here in Jamaica, it is undoubtedly true that many of the phenomena recorded would be difficult with the inferior atmospheric conditions existing in the north. It has therefore always been the writer's aim to find and describe the most conspicuous changes that he has been able to detect. A marked irregular change recently occurred in Eimmart, and has been described by him in *A.N.* 4704, but there are regular changes constantly occurring within that crater, in some cases differing from one lunation to another, of about the same degree of visibility as these observed upon Pico.

With his 3-inch finder and a magnification of 180 he has been able to see clearly spot *d*, *d'* on Pico, and to suspect *f*, at about the time of full moon. With a somewhat larger aperture these and perhaps some of the others should be visible in the north, so that it should be possible to record the times of their appearance and disappearance. The same should be true of the two spots on Pico *B*.

Among the most difficult observations to confirm would probably be those relating to the so-called snow storm on Pico *d*. Where the seeing is continually bad, all outlines are indistinct, and little difference would therefore show even between *d* and *f*. Where on the other hand two or three diffraction rings are almost stationary around the brighter stars, with the full aperture of 11 inches, and a magnification of 800, as occurs here with our best seeing, 12, it is easy to see that details on the moon present a sharpness of outline quite unknown in the north. That certain bright spots such as Linné are always hazy is well known. The peculiarity of Pico *d* is that it is hazy only at specified seasons on the moon, when other neighboring and similar spots are sharp.

There are, however, other objects on the moon, similar in their characteristics to *d*, which are much easier to observe. One of these is Sulpicius Gallus *B*, so designated on Goodacre's map, but not shown by Neison. The crater is located in longitude 351°, latitude +20°. On its eastern interior wall there is an intensely brilliant pear-shaped spot, very conspicuous just before full moon. It clearly changes its shape at different times, and is very hazy and indistinct between colongitudes 30° and 120°, although sharply defined earlier and later in the lunation. The duration of the indistinct period is thus much greater than on Pico *d*, and the change in appearance is so marked that the writer feels convinced it should be capable of detection in the north.

It has recently been found that the western end of the Straight Range presents changes that are fairly conspicuous. The sunlight first strikes it at colongitude 20°. It is then intensely brilliant, especially at its northern edge. By 44° it is rather less bright. By 70° all the snow has gone except at the north and the bare rock, of brightness 6, looks red in contrast with the greenish *mare*. At 82° faint whitish streams, of brightness 7, begin to cover the rocky face. These have further brightened by 90°, but by 103° have again largely disappeared. The formation has been under observation for so short a period, however, that this description should be looked on merely as an indication of what may be expected, rather than as a finished report of what generally occurs.

Turning now to quite a different type of formation, we find scattered over the moon's surface, but especially in the equatorial regions, a series of small craterlets whose interior walls under all illuminations are of dazzling brilliancy. The floors of the smaller ones are also bright. One of the best known of these is Mösting *A*, some 5 miles in diameter, 3000 feet deep, and situated in longitude 5°, latitude −3°. On January 27, 1915, at colongitude 56°.3, the shadow still showed within the crater, but had entirely cleared the center of the floor, which appeared of a uniform brilliant white, without detail. On March 19, 1913, 61°.0, a minute black dot was detected at the center, of less than half a mile in diameter. It was also observed February 18, 1913, 66°.0. On January 28, 1915, 70°.1, the dot was clearly seen, was about a mile in diameter, and was of the same darkness as the region surrounding the crater. Accompanying the dot, and reaching from it towards the north, three-quarter of the way up to the rim, was a faint dark band one mile in breadth. This was observed March 20, 1913, 71°.4, though of slightly greater breadth and much greater density, and also on January 29, 1915, 82°.0. No change was detected March 21, 1913, 85°.7, but February 2, 1915, 132°.5, the shadow had appeared on the eastern side, and the canal had almost completely faded away. The next night both the canal and cen-

tral dot had vanished, and the floor was a uniform white. The crater is clear of shadow for about 70° of colongitude. Herschel *c* and Lalande *D* exhibit similar peculiarities. In *c* the canal extends towards the west, and in *D* northwest. In all cases as the sun rises higher and higher upon them the snow melts, and after midday forms again.

We will turn now to another type of white spot, the only one which has been investigated micrometrically. We refer here to Linné. An account of it is given in the *Harvard Annals* **61**, 100, where measures by the writer in 1897, 8, by Professor Barnard in 1902, 4, and by Professor Wirtz in 1904, 6 are compared. All three agree in showing a marked diminution in size as the lunation progresses, up to a certain point, and after that an increase. According to the first two the minimum size is reached at about 12° past midday for Linné, and the diameter about sunset is slightly less than about sunrise. Professor Wirtz on the other hand finds the minimum size occurs 12° before midday, and the diameter at sunset to be much larger than at sunrise, which would indicate a certain melting during the lunar night. All three agree however that the diameter fluctuates through a range of about 3″. Irregular changes in the shape of the spot and its surroundings were noticed by all three observers.

Thus Professor Barnard, on September 1, 1903, detected a small bright point preceding the spot, 5″.4 from its center. On February 12, 1905, Professor Wirtz saw two irregular extremely delicate bright offshoots on the otherwise well rounded spot, which offshoots the next day had disappeared, leaving the spot slightly elongated. Other observers besides the writer have found the size of the spot to increase slightly at the time of a lunar eclipse, so that a certain amount of literature upon the subject has already accumulated.

Mr. J. G. Burgess of the British Astronomical Association has recently called my attention to a spot situated some twelve miles north of Littrow *B*, in longitude 330°, latitude +22°, which is of the Linné type, and according to his description should be of greater interest than Linné itself at the present time, since it contains considerable fine detail close to the crater. His statements are in part confirmed by the writer's Photographic Atlas, H. A. **51**. Mr. Burgess proposes soon to publish an account of his observations, the results of which in general resemble those made upon Linné. The writer examined the region February 2, 1915, at 132°.8, and found a very thin white veil, whose density was 0.2 of a unit of brightness, covering it at that time. This veil was 6 miles in diameter. The next night it had entirely disappeared. This spot should be of particular interest at the time of a lunar eclipse, since the detail near the crater should make drawings

available, thus avoiding some of the subjective systematic errors incident to micrometric measurements.

It has been the writer's object in the present article to show, not that periodic changes occur in the brighter regions of the lunar surface, for that was known before, notably in the case of the region surrounding Tycho, but to show in just what these changes consist. For this purpose he has selected small bright spots lying in regions showing sharply defined minute detail, in order that the minute changes everywhere occurring upon the moon could be more clearly defined. In order to make the study general, he has also selected the three different types of surface, elevations, depressions, and level areas.

The point of first interest perhaps in this investigation is to find when the spots reach their minimum size. Within the craters, the dark areas appear and disappear at about the same interval before and after midday, which therefore seems to be the time when the snow presents the smallest area. In the case of Linné, Professor Barnard and the writer agreed that the minimum occurred one terrestrial day after lunar midday. Since the deviations of their observations from their respective curves were appreciably smaller than those of Professor Wirtz, doubtless due to better atmospheric conditions in America, and since a minimum occurring after noon seems more probable than one occurring before it, the writer has adopted that view. It would certainly be of interest to prepare a series of drawings of the craterlet near Littrow *B*, and determine when its minimum occurs. In the case of Linné and apparently also of Littrow, the white spot is invisible both at sunrise and sunset. Just why this should be so is not very clear, but it would seem to indicate that the moisture can only escape from the vent about midday, and that towards sunset it all evaporates. Towards noon the evaporation occurs before it can get far from the vent, hence the spot is smaller, although brighter at that time than earlier or later.

In the case of the mountains, Pico, Pico *B*, and Straight Range, most of the white spots grow smaller the longer the sun shines on them. Those on the west side of the mountains, towards the rising sun, are of full brightness when the sun first strikes them. Those on the east do not deposit until the sun has been shining on the region for a day or two. It appears as if the ground some little way beneath the surface must be heated up before the moisture can escape. The spots on the western side, on the other hand, must be formed very shortly after the sun sets on them, but while it is still daylight in the surrounding region, for it is clear that nothing can deposit during the night, or both sides of the mountain would be brilliant when the sun first reached them. Pico *c* was seen in January 1915 distinctly to grow in size, and spread over the dark surface of the

mountain between colongitudes 9°.0 and 16°.6. It then decreased in area until 32°.9, Figure 2, after which it increased a second time in size until 55°.9, Figure 3, and then rapidly diminished until 68°.1. It had not changed at 81°.8, Figure 4, but when the region was next observed at 132°.2, the spot was found to have disappeared.

The writer has sometimes been asked, "What reason is there to believe that there is ice upon the moon?" The answer is: "For the same reason that we believe there is ice upon Mars, because the phenomena observed can be more readily explained that way than any other." Whether the ice is deposited upon the surface, or floats as minute crystals just above it, in the form of surface clouds or fog, is not yet clear, but it is believed it occurs in both forms. Where the boundaries are sharply defined. it lies upon the surface. Where the boundaries are indistinct and hazy, as for instance in the case of Linné it is still uncertain. In the case of the bright rays surrounding Tycho, it is thought the ice crystals are supported in the lunar atmosphere like those terrestrial cirrus clouds to which we give the name of mare's tails.

CAPELLA.

When azure Vega glitters bright and low,
And sere December comes with winter's blight,
When last leaf falls and days still colder grow,
Again Capella shines with brilliant light;
Like lofty beacon blazing in the sky
Or starry diamond flashing clear and white,
Auriga's queen is seen afar and nigh,
And reigns enthroned amid the suns of night.

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MODERN IDEAS ON COSMOGONY.

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INTRODUCTORY STATEMENT.

Modern * ideas on cosmogony, or world-origin, are many. But among those extant by common consent of astronomers, these three stand out with a certain distinctive importance which merits their general acceptance as the leading representative views of today: the ring nebular hypothesis of Laplace, the meteoritic hypothesis of Lockyer, and the planetesimal hypothesis of Chamberlin and Moulton. A comprehensive account of these theories, *i. e.*, one including, first, a complete recital of all the facts of the universe upon which they are based, and, second, the various objections that can be raised to them, would exceed many times the bounds of a single short paper. The purpose of this article is, therefore, to review the most important features of the three hypotheses as they were originally presented. No attempt will be made to elaborate them with present-day modifications or to supplement them with comments on their probable inconsistencies with the observed phenomena of nature. Rather is there left to the reader the task of making a fair consideration of all, and of drawing his own conclusions on a subject so profound.

THE RING NEBULAR HYPOTHESIS (1796).

Of all the ideas of world-origin, the one which has created the most discussion among astronomers has indubitably been that of the great French mathematician Laplace. Although his hypothesis was considerably anticipated by the early brilliant speculations of Kant and by the cosmogonical conceptions of Swedenborg,† Kant's were in turn suggested by those of Thomas Wright;‡ there appears to be no evidence, however, that Laplace was ever familiar with these theories of Kant. Notwithstanding the fact that the ring nebular hypothesis was given to the world as early as 1796, in the publication of the admirable *Exposition du Système du Monde*, yet, with some modifications

* By "modern" is meant theories current since the middle of the Eighteenth Century.

† Set forth in his *Principia* (published 1734).

‡ Regarding the evolution and construction of the entire sidereal universe (published 1750).

which have not materially altered the original statement of the theory, it has, at least until very lately, justly stood the test of time. Nor by some practical astronomers is it at the present day considered obsolete. In a recent address, Professor Edwin B. Frost has said: "It is true that this theory of Laplace is inadequate in some respects, and is mathematically unfounded in some particulars. Its premises need modification, and it also leaves much unexplained. But no adequate substitute has been proposed, and the increased study of the different phases of development, as inferred from stellar spectra, supports the Laplacian theory surprisingly." These remarks may be taken as typical perhaps of similar views shared by a number of other contemporary astrophysicists.

Laplace commenced his discussion by pointing out that all the movements of rotation and revolution of the then known members of the solar system were effected practically in the same plane and in the same general direction, and that, moreover, the orbits described by the planets were nearly circular, while those pursued by the comets were mainly parabolic in shape. Since he had calculated that such a condition would not occur by chance more than once in five hundred million contingencies, he reasonably supposed that it was due to some factor in the evolution of the system itself. He imagined that at the time assumed to be the starting-point of the development of the system,* there existed a vast rotating nebula, an attenuated and highly heated gaseous envelope, doubtless of greater temperature than that of the sun at present, and extending out into space beyond what is now the orbit of the farthest planet. As this enormous mass cooled and contracted, having taken first, under the influence of the mutual attractions of its parts, a roughly spherical shape, and as it diminished in bulk, by the laws of contracting bodies its motion of rotation gradually accelerated. Then as the nebula increased in its speed of rotation, it necessarily became flattened at its poles and bulged at its equator, and there probably came a time when the centrifugal force at the equatorial periphery was sufficient to overcome the gravity of the body. Thus, in the plane of its rotation, the central mass left off concentric nebulous rings,† one after another, at the respective distances from its nucleus at which the planets are now situated from the sun. In time, the matter composing the rings disintegrated and ultimately it coalesced into globes, so producing the planetary masses. Likewise these masses abandoned rings which furnished them with an accompaniment of

* Though by no means the beginning of the *matter* composing it.

† These rings would no doubt be similar in appearance to those of Saturn which, in fact, were probably what suggested this feature of the theory to Laplace.

satellites. Finally, the central nucleus and the planetary and secondary nuclei, after a long-continued process of cooling, contraction and rotation, developed successively into the sun, the planets and their satellites, the first, by reason of its supereminent bulk, remaining incandescent long after the lesser orbs had cooled or grown even entirely cold, *e. g.*, like our moon.

Though it is not necessary to enter here into a criticism of any of the details of the ring nebular hypothesis, obviously difficult as many of them are to reconcile to conditions actually existent in the solar system, it is seen that, according to it, out of a chaotic gaseous envelope were thus evolved in turn the sun, the planets, and the satellites. How their development came about will now be considered as it is explained by the meteoritic theory.

THE METEORITIC HYPOTHESIS (1890).

What may be regarded as a modification of Laplace's view, principally in that the matter composing the original solar nebula is assumed to have been of *meteoric* constitution rather than of *gaseous*, is the meteoritic hypothesis of Sir J. Norman Lockyer. This idea, which has gained considerable prominence, but which Lockyer has told us was by no means first propounded by himself, will nevertheless always be inevitably accredited to him, both because of his acceptance of the view and the vindication that he has received for it from elaborate experimental researches on the spectra of meteorites under varying states of incandescence.

Lockyer claims to have discovered in the laboratory spectra of meteorites a certain correspondence to those of all the spectral types of stars, of nebulæ and of comets, and even to the spectra of such phenomena as the auroræ and the zodiacal light. He believes that this marked similarity has important relations to the question of cosmic evolution. But in order to understand his point of view, it will be well to know his definition of a nebula, which he gives in these terms:*

"A true nebula consists of a sparse swarm of meteorites, the luminosity of which is due to the heat produced by collisions. The interspaces are partly filled with hydrogen and magnesium and other vapors, which are volatilized out of the meteorites. Amongst true nebulæ, are the great nebula in Orion, that surrounding η Argûs, the ring nebula in Lyra, and all planetary nebulæ." Upon this assumption, he argues that as the aggregation of the particles in nebulæ continues, they evolve into stars by ordinary condensation and accretion, and that as these stars pass

* *Elementary Lessons in Astronomy*, p. 42.

through their long complicated life-cycles, the temperatures of the bodies gradually attain a maximum and then decline so that the stars are ultimately reduced to non-luminosity. He further presumes that each successive period in this evolution is duly marked by its corresponding typical spectrum.

Sir George H. Darwin has demonstrated mathematically that a meteoric swarm of the dimensions and mass of the solar system, consisting of individual particles of the sizes of meteorites that fall to the earth, and endued with velocities equal to the known velocities of meteors, would, if observed from interstellar distances, show no phenomena differing perceptibly from those of a mass of continuous gas; and that, if the swarm were dissipated sufficiently, it would rotate like a solid. Under the kinetic theory of gases, however, such deductions are to be expected, because, according to it, a gas is itself an immense collection of molecules moving similarly to the way the meteorites are conceived to move in the meteoritic hypothesis. But Professor Young maintains that "it follows that the *meteoric* theory of a nebula does not in the least invalidate, or even to any great extent modify, the reasoning of Laplace in respect to the development of suns and systems from a *gaseous* nebula." Hence, Lockyer's theory, as applied to the solar system, is dynamically identical with Laplace's.

The hypothesis of Lockyer explains all the evolutionary phenomena of the heavenly bodies entirely on the basis of differences in temperature. His whole theory may therefore be well summed up by his own words on p. 247 of *Elementary Lessons in Astronomy:* "We begin with sparse swarms of meteorites at low temperatures, pass through the various phenomena of increasing temperatures to stars like Vega, then through those of decreasing temperatures, finally ending with cold, condensed and consolidated masses. Further, it is possible that bodies of the latter kind may collide as individual meteorites do, and by such collisions become again resolved into swarms of meteorites, *and thus complete the celestial cycle.*"* It is interesting to note, both in Lockyer's hypothesis and in the one about to be reviewed, the distinct tendency toward a possible cyclical explication of the evolution of stars and systems.

THE PLANETESIMAL HYPOTHESIS (1900).

The first published account of the planetesimal hypothesis was presented by Professor T. C. Chamberlin in a paper in *Year Book No. 3 of the Carnegie Institution of Washington*, entitled *Fundamental Problems of Geology;* another exposition of the same theory, by

* The italics here are mine.

PLATE IX

SPIRAL NEBULA, *M* 51 *Canum Venaticorum*

Photographed with Two-foot Reflector of Yerkes Observatory
by G. W. Ritchey, 1902.

Reprinted by permission from the *Astrophysical Journal*, Vol. XXII.

Professor F. R. Moulton, the co-author, with Professor Chamberlin, of the hypothesis, has since appeared in the *Astrophysical Journal* for October, 1905, *On the Evolution of the Solar System.* The following extract is taken from the latter paper: "It is supposed that our system has developed from a spiral nebula, perhaps something like those spiral nebulæ which Keeler showed are many times more numerous than all other kinds together. The spiral nebula is supposed to have originated at a time when another sun passed very near our sun. The dimensions of the nebula were maintained almost entirely by the orbital motions of the great number of small masses of which it was composed, and only a very little by gaseous expansion. It was never in a state of hydrodynamical equilibrium, and the loss of heat was not necessary for its development into planetary masses. The planets have been formed around primitive nuclei of considerable dimensions by the accretion of the vast amount of scattered material which was spread throughout the system." In his *Introduction to Astronomy*, p. 464, Professor Moulton writes, "Because of the fact that every particle is supposed to have moved nearly independently like a planet, Chamberlin calls the theory the *Planetesimal Hypothesis.*"

Not long prior to his death in 1900, Professor James Edward Keeler, director of the Lick Observatory (1898-1900), made an extended photographic investigation of nebulous regions in the heavens. From his photographs he was led to the general conviction that the spiral nebula (one of the most beautiful representatives of which is herewith reproduced, Plate IX) belongs to the usual and predominating class of nebula. He stated that at a conservative estimate there were probably as many as one hundred and twenty thousand such objects accessible to the 3-foot Crossley Reflector of the Lick Observatory. He further called attention to the remarkable fact that "Most of these nebulæ have a spiral structure," and stated that "While I must leave to others an estimate of the importance of these conclusions, it seems to me that they have a very direct bearing on many, if not all, questions concerning the cosmogony. If, for example, the spiral is the form normally assumed by a contracting nebulous mass, the idea at once suggests itself that the solar system has been evolved from a spiral nebula, while the photographs show that the spiral is not, as a rule, characterized by the simplicity attributed to the contracting mass in the nebular [Laplacian] hypothesis. This is a question which has already been taken up by Chamberlin and Moulton of the University of Chicago." From a spiral nebula, similar, though undoubtedly far inferior to that transcendent mass delineated in the accompanying photograph, according to the planetesimal theory, the solar system has been evolved. We shall now trace briefly the various essential steps of the hypothesis.

It is reasonable to imagine that, in the passage of one sun, or star, through space, it may at some period in its course pass near to, or very infrequently, actually collide with, another sun.* When two large cosmical bodies come within proximity of each other, they are subject to violent tidal strains, which are due to their mutual attractions. As one star, S', approaches another, S, it will follow therefore that an immense tide will be produced on the side of S *toward* S', and one almost equally as great, on the *opposite* side of S, and that matter will continually be erupted by S in the direction of S'.† Now as S' continues to move, its line of motion will be deflected from the original course on account of the gravitative attraction of S, so that S' will be compelled to describe a parabolic or an hyperbolic curve around S. As S' moves in this curve, it will drag the ejected material of S around in the direc- of the motion, instead of allowing the eruptions to precipitate themselves back upon S, as they normally would, if not affected by any exterior forces, until S will, before long, have the appearance of a huge spiral with two great arms coiled around from two diametrically opposite points on the central nucleus.

Concerning the present appearance of the spiral nebulæ, Professor Moulton writes‡: "When we see a spiral nebula we do not see the paths which the separate masses have described, but the positions which they occupy at the time. .....if a smooth curve is drawn through the regions where the matter is densest, it will form a sort of double spiral.....There will be nuclei here and there along the arms of the spiral where large masses have been ejected, and the whole space will be more or less filled with finely divided and nebulous material. It must be remembered that *the matter does not move along the arms of the spiral*, but in orbits which cross them at right angles. The particles in the smaller orbits will move faster than the outer ones, and the spiral will become more and more coiled with age until its spiral character can no longer be discerned. In the photographs of spiral nebulæ the *two arms* can nearly always be easily made out, and it is significant that no other number is certainly found. But it is almost certain that the spiral nebulæ which have been photographed are much greater than the one from which our system may have developed."

To account now for the planets, the satellites, and the sun, from the primitive spiral: It is assumed that the planets have developed from the larger nuclei scattered throughout the nebula, which were increased

* As a matter of fact, it has been computed that a near approach does really happen to a star on the average of once in a billion years.

† This matter would resemble the eruptive prominences on the sun, only it would be on an enormously greater scale than they are.

‡ *Introduction to Astronomy*, pp. 469-70.

in volume by the gradual accretion of the smaller masses whose orbits intersected or passed near to theirs. The major planets can easily be explained on the possibility that their paths lay in regions of the nebula where the material was densest, and the asteroids as simply the lesser nuclei not in those parts of the spiral in which the matter was swept up by the greater globes of the system. As these large masses left the sun S, they were accompanied by multitudes of smaller secondary masses. If their velocities became too great, these bodies escaped from the gravitative control of their primaries. If, on the other hand, the velocities were too feeble, the masses were absorbed by the superior globes and so lost their individuality. But if the rates of motion could not overcome that attraction entirely, yet were strong enough to resist it sufficiently, the secondary bodies were forced to remain as satellites circling about the planetary nuclei. Our present sun is merely the ultimate result of the development of the central nucleus of the spiral, which originally was the star S in the hypothesis.

The subsequent physical conditions of the several planets, as explained by the planetesimal theory, are especially interesting to trace, but are best described by Professor Moulton himself:* "The evolutions of the small and large planetary nuclei have been quite different. They were all very hot at the time of their ejection. The small nuclei did not have sufficient gravitative control to retain their lighter gases. In a comparatively short time they had no appreciable atmospheres, and they speedily cooled until they became solid. The meteoric matter which fell in upon them was also in a solid state. The relative velocity was in general so small that no great amount of heat was generated by the impact, and what was produced speedily radiated away. After the masses began to assume earth-like dimensions the interior pressure became very great and they diminished in volume. This shrinking produced *interior* heat just as it does in the case of the sun.....

"The earth acquired its atmosphere chiefly after it became about as large as Mercury. The atmospheric gases came from the interior, squeezed, as it were, out of the heated and compressed material. Bodies much smaller than Mercury have never retained any real atmospheres. This applies to most of the satellites and to all of the planetoids.

"On the other hand, the large planetary nuclei were so massive that they never lost their light gaseous envelopes. Because of this their original heat was largely retained, and they have not yet contracted to any great extent. They are less dense than the smaller planets both because they retained nearly all of the original light elements, and also because the conditions have been unfavorable to their cooling and contracting."

* *Introduction to Astronomp*, pp. 484-5.

There is a decided hint in the last two paragraphs of the foregoing quotation respecting what planets of the solar system might best be considered as possible abodes for life not entirely dissimilar to that with which we are familiar on earth; especially do the comments about what planets could and could not retain an atmosphere concern this point. A discussion of the subject would, however, lead far beyond the limits of the present paper into the sphere of interesting, but endless speculation.

CONCLUSION.

It were redundant to call further attention to the striking departure of the planetesimal theory of Chamberlin and Moulton, both from the time-honored ring nebular hypothesis of Laplace, and from Lockyer's modification of Laplace's idea. Whether the later view will succeed entirely in supplanting the earlier theories is still a pregnant matter for conjecture and revelation, and one certainly of great interest to astronomers.* That each of these hypotheses has in its turn been an epoch-making contribution to the sublimely theoretical and philosophical departments of astronomical science may aptly be affirmed. The following and concluding paragraph of Professor Moulton's paper *On the Evolution of the Solar System* well illustrates the general trend in cosmologies today:—

"The spiral theory is fertile in suggesting new considerations for interpreting the immense variety of special phenomena of the system It is not too much to expect that it may suggest new questions for observational investigation. It affords geologists new conceptions of the early history of the earth. But perhaps its most interesting contribution is to our general philosophy of nature. Heretofore we have regarded the cosmical processes as forever aggregating matter into larger and still larger bodies, and dissipating energy more and more uniformly. Now we recognize important tendencies for the dispersion of matter. This idea has introduced an element of possible cyclical character in the evolution of the heavenly bodies, though the question of the source of the requisite energy is serious. There is hope that the difficulties of this question may soon be relieved, for recent discoveries respecting the internal energies of atoms suggest the possibility that the Helmholtzian contraction theory explains the origin of only a part of the energy given up by the stars."

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* The planetesimal hypothesis may be correct, even though the suggested origin of the spiral nebulæ is false. Professor Moulton has stated (*Introduction to Astronomy*, pp. 465-6): "The theory of the evolution of the system from a spiral nebula is largely independent of any hypothesis about the origin of the spiral. However, a possible, and even probable, mode of generation of these remarkable forms has been suggested by Chamberlin; and for the sake of having a definite theory to work on, it will be assumed, at least provisionally, that the solar spiral nebula was developed in this way."

THE PLANETARY NEBULAE.

RUSSELL SULLIVAN.

When Sir William Herschel first turned his powerful reflector to the skies, he noticed a number of small round discs of greenish light. He assumed that they were either distended stars, or comets at aphelion, or the planets which revolve around the stars. After testing these hypotheses, he cast them aside and decided that these tiny discs were hollow shells of gas.

The term "Planetary nebulæ" was used by Sir William to denote these objects and has caused confusion at times. It refers to the resemblance these nebulæ bear to the disc of a planet and not to any planetary affiliations.

In the early sixties Sir William Huggins spectroscopically examined the bright planetary nebula in Draco, which marks the pole of the ecliptic and showed that the spectrum consists of a few bright lines which indicate luminous gas under little or no pressure. This discovery, so different from the well known continuous spectrum, might be called the beginning of nebular astronomy. Thus the spectroscope made it possible to differentiate between nebulæ and distant star clusters.

In recent years the planetary nebulae have been somewhat neglected. Little was known until Keeler visually measured the radial velocities of a few and found their average speed was about 16 miles per second—comparable to that of the stars. This remarkable result was obtained before the days of photographic work with the spectroscope. He also attempted to measure their rotational velocity, but without definite result. If it were not for the concentration of light in a few lines the spectra of these objects would be almost invisible. Babinet's criterion, applied to a planetary nebula, would show that the rotation of a huge, attenuated mass of gas would be almost nothing at the circumference. Campbell has recently measured the radial velocity of the planetary nebulæ by the spectrographic method and confirms Keeler's earlier results obtained visually. In the last three years Campbell has found planetaries whose average speed is seven times that of the average helium star, i.e. the earliest type of star. These stars are the slowest known and have an average radial velocity of 5½ miles per second. Thus the planetaries would be moving through space with speeds of 40 miles per second. Such speeds are only com-

parable to the very high velocities of the faint small stars which Eddington has recently described. These stars are only visible because they are near—the distant ones being too faint for observation. Eddington finds average speeds of 42 miles per second for this class.

The number of planetaries is not large—they can be counted by the score; while the spiral type runs into the thousands. Hydrogen, helium and nebulium (the latter terrestrially unknown) are the principal gases which form these strange bodies, and there is often a central star or haze, implying a certain degree of condensation which would contradict Herschel's theory of a hollow sphere. Some planetaries present an elliptical aspect and it is evident that others consist of two or three spheres of gas. The majority are probably spheroidal and under high powers show a mottled or slightly ragged disc. All planetaries, with a few exceptions, lie in or near the plane of the Milky Way. In fact almost all gaseous (i.e. "green") nebulæ lie in or near the galactic plane.

There are more planetaries in the Southern Hemisphere and the available evidence tends to show that they are numerous in the Greater Magellanic Cloud. Almost nothing is known about their motion at right angles to the line of sight. The fact that few planetaries have wandered far from the galactic plane would imply that this component is small. Why should they have high speeds and still keep to the plane of the Milky Way? One would expect lower velocity in conformity with the average early type star of the galactic plane. Nor has anything been learned concerning their distance or dimensions; they are presumably very remote, as their close association with the plane of the Milky Way would imply, and in size must enormously exceed a globe whose diameter is equal to that of the solar system. Their low galactic latitude makes it certain that they are *en rapport* with the Milky Way and thus are not external to our own universe.

Stellar nebulæ seem to be small or distant planetaries. Pickering has found a number of them by sweeping with a direct-vision spectroscope; they are faint, minute and almost star-like in appearance. Miss Clerke thinks them similar to the planetaries. They are gaseous and never lie outside the plane of the Milky Way.

Wright, Merrill and Paddock have recently found that there is a pronounced resemblance between the spectra of stars of the Wolf-Rayet type and the planetaries. At least three planetaries yield Wolf-Rayet bands. A bright planetary in Ophiuchus (N.G.C. 6572), which has a nucleus, and a Wolf-Rayet star in Cygnus (BD + 30° 3639, found by Campbell to have an hydrogen envelop 5″ of arc in diameter) are spectroscopically planetary nebulae with Wolf-Rayet stars for nuclei. Both classes of spectra lack the metallic lines common to the older types of stars. The Wolf-Rayet stars are usually assigned to Type O,

the beginning of stellar evolution, and have small average radial velocities, whereas the planetaries have average speeds several times as great. It is difficult to reconcile such facts. The Wolf-Rayet type is noted for its adherence to the galactic plane and a score or so of these stars lie in the Magellanic Clouds as well.

Fading Novae often assume the planetary stage on their downward career. Bickerton thinks that they have been struck off as "third bodies" after a stellar collision and continue their existence as expanding hollow shells of gas. The Novae have not shown positively that their nebular stage is permanent, as the majority have eventually assumed a faint continuous spectrum and have become small stars. In this connection it may be interesting to note that Novae often show Wolf-Rayet bands in their intermediate stages, followed by the spectrum of nebulium. Thus the Wolf-Rayet and planetary spectra would appear consecutively. Miss Clerke thinks that this period is the middle of a Nova's life. Campbell suggests that planetary nebulae originate by stellar collision or close approach. Before a star becomes a Nova the chances are that it has gone through several stages of stellar evolution and has thereby acquired a velocity comparable to that of the fast Type M Star (10½ miles per second) or the planetary nebulae; Eddington says the speed is still greater for fainter stars of that type. If the planetaries were as numerous as the stars we might infer a genesis of planetaries from old stars. Since they are comparatively scarce it seems more likely that they are the wrecks of ancient Novæ. The number of planetaries and Novae is in fair agreement and both classes lie in or near the plane of the Milky Way.

Campbell arranged a number of stars in the order of their spectroscopic age and showed that the planetary nebulæ exceed the oldest stars in speed. According to Keeler, the great nebula in Orion, of the *irregular* gaseous type, is almost at rest in space. Evidently one gaseous type is much older than the other and there may be unknown stages of stellar evolution connecting the two gaseous types. If increasing radial velocity is a measure of a star's age, are we justified in applying this criterion to the nebulæ?

Thus the planetary nebulæ have Wolf-Rayet affinities and are related to the Novae as well,—the Novæ also showing an intermediate Wolf-Rayet spectrum. The interpretation of these relations is one of the tasks of modern spectroscopy.

AN EXPLANATION OF GYROSCOPIC ACTION.

C. M. KILBY.

An article in a recent issue of POPULAR ASTRONOMY states that many theories of gyroscopic action have been advanced but that "none of them will satisfactorily explain the phenomena." On the contrary it might be stated that gyroscopic action is fully and completely understood. No "unknown law" is necessary for the explanation, for the simplest of all scientific laws—Newton's first Law of Motion,—is entirely adequate. This law is but a matter of common every-day experience—the law of Inertia.

A part of Newton's First Law of Motion states that a body, whether at rest or in motion, will continue at rest, or in motion, and if in motion will continue to move without suffering any change of direction (i.e. will move in a straight line) or of speed, unless it is acted on by some external force. This may be more tersely expressed by saying that an inanimate body can not of its own accord change its velocity, i.e. either its speed or its direction of motion. This is simply a matter of common experience. It is at least implied in this statement that a force is required to change the speed or the direction and also that the body exerts a reacting force against the applied force. If it did not exert a reacting force, no applied force would be necessary to change the motion, as there would be no resistance to be overcome by the applied force.

The explanation of gyroscopic action follows directly from this first Law of Motion and its corollary, the so-called third Law of Motion.

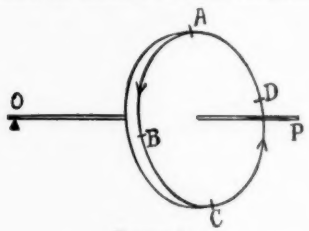

FIGURE 1.

Consider four particles *A*, *B*, *C*, and *D* on the periphery of a rotating wheel (Fig. 1.) Let one end of the axle rest on the supprt *O*, and suppose the wheel is rotating as indicated by the arrow heads, i.e. from *A* towards *B*.

If the end of the axle *P* is left free there will be an unbalanced downward force (gravity) tending to produce rotation of the wheel and axle about a horizontal line through *O* and perpendicular to the axle. As the spinning wheel starts to fall because of gravity the directions of the moving particles *B* and *D* (not *A* and *C*) change and new forces are thereby brought into play.

Gravity acting tries to put the wheel in the position represented by Fig. 3, and the particle *B*, which at any instant was moving in direction *BE*, would in this new position be moving in direction *BF*. Accordingly, its direction would be changed, and by the Law of Motion a force on *B* is required to make this change, viz., gravity. Also, by the law *B* tries

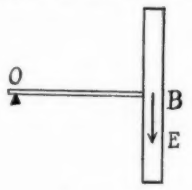

FIGURE 2.

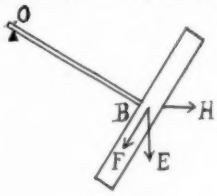

FIGURE 3.

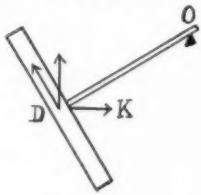

FIGURE 4.

to continue in its original direction *BE* and therefore pulls in the direction *BH*, away from *O*. The particle *D* on the opposite side of the wheel acts likewise but in the opposite direction, as shown by Fig. 4, that is, towards *O*. These two pulls of *B* and *D*, on opposite sides of the axle produce a torque about the pivot *O* and therefore the wheel and axle move around *O* in a horizontal plane. This motion of the axle is called precession.

When this precession takes place, the directions of the particles *A* and *C* are changed and their reacting forces cause a torque about the pivot *O* in a vertical plane, which prevents the gyroscope from falling.

What has been said in regard to the four particles *A*, *B*, *C*, and *D* is applicable to all particles composing the wheel, for their directions at any moment, or in any position, can be resolved into two of the four directions of *A*, *B*, *C*, and *D*. As the wheel is spinning all particles play a part, and the faster the spin the greater the total force of inertia.

Accordingly gravity causes precession and precession prevents the falling, and if the precession is sufficiently great it may cause the wheel to rise above the horizontal plane of the pivot, as a top does (but not for exactly the same reasons).

If both ends of an axle of a rotating fly-wheel are fixed and the direction of the axle is forcibly changed, there will be a reacting force on the bearings at right angles to the direction of the enforced precession, as may be seen by considering the four particles of the wheel, Figure 1. An auto turning a corner furnishes an example of this. The greater the speed of the fly-wheel and the quicker the turn, the greater will be the reaction on the bearing. The direction of the reaction will be perpendicular to the plane of the motion of the axle (i.e. to the horizontal plane) and further determined by the direction of the spin the fly-wheel and of the turning of the car.

If the fly-wheel F is spinning as represented in Fig. 5 and the car is turning in direction C the shaft will press downwards on the bearing A and upwards on the bearing B. The force of this reaction is far

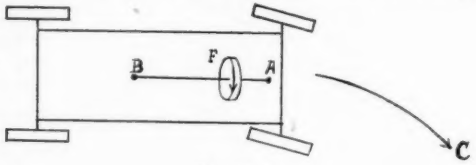

FIGURE 5.

greater than is imagined by many auto owners and produces tremendous strains when the engine speed is high and the turn sharp.

FIGURE 6.

If knowledge of Vectors and Rotors could be assumed, the action of gyroscopes could be explained more briefly (Fig. 6 represents the reaction of the auto), but its elementary scheme shows clearly why gyroscopic action (or reaction) is at right angles to the plane of the enforced motion, or to the applied force, and why it precesses and does not fall when pivoted at one end.

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ASTRONOMICAL TEACHING IN THE CITY.

MARY E. BYRD.

Those who have watched the heavens from the western prairies, or the hilltops of New England, find the sky in the city like the face of a stranger. The glare of electric lights and the overhanging pall of dust and smoke blot out the glory of the stars. Long to be remembered is my first view of the evening sky in the city of New York. The place was favorable, for no high walls interfered, the moon was young and the seeing fair. But when I looked up and saw how many stars were missing, and that even Orion was dim, my heart sank; for seventy students were depending on me for guidance in mastering the constellations, and solving problems that demand actual observation of the heavenly bodies.

During the year and more that followed, the difficulties were so many and so great that they were fairly inspiring. The mere assembling of sections in the evening was so serious an under-

taking that it threatened to put an end to my work before it began. The students were scattered over New York, Brooklyn, Long Island and the neighboring sections of New Jersey. Evening periods had to close early, about nine, and then not a few failed to reach home till eleven. My pretty Spanish girl was met by her father "on the bridge at midnight," but never once did she miss her night a week.

The lack of stability was a constant and fruitful source of trouble. Nothing was fixed. The whole building trembled and vibrated from the jar of trains and heavy wagons, and it was shaken to its foundations by the blasting going on for the new subway which passed almost under us. Over and over, again and again, instruments had to be adjusted and tested. Excellent results would be obtained on one day, perhaps, and on the next, through no apparent fault of any one, every observation would be "wild".

Incidentally, there were obstacles in the way of obtaining warmed and lighted rooms at night. When I pleaded with the janitor (city janitors are important folk) to put on a little heat at night, he said it could not be done; and during one March, only a cold room was accessible for desk work when all were chilled from out-of-door observing. Heat was secured the following October, but no lights, except as teachers and students groped their way, in the dark, through halls, up and down stairs and over a connecting bridge, the length of a city block, into another building!

Fortunately, few mechanical appliances are required in the first study of astronomy, and those available in the New York College would have met very well the needs of twelve or fifteen students. Space, however, costs in the city, and it seemed impracticable to multiply apparatus so that seventy or eighty could work to advantage. There was only one south window to be had for a gnomon, and it was so high above the floor that students who were small of stature, in order to measure lines and angles conveniently, had a strong predilection for climbing up on the projecting board, a procedure that naturally added to the difficulty of maintaining a true level and accurate meridian lines. Ah, how many eager, young eyes watched that gnomon, and how unkindly the walls near by delayed the coming of the sun's image in the morning and hastened its departure in the afternoon. The removal of the sheet of paper from this board was little short of a tragedy. Though it was done only two or three times a year, it was not possible to find a date suited to all, and some-one's "dots" had to be sacrificed. They looked insignificant enough, tiny pencil marks surrounded by small circles and marked with initials. And yet every one stood for an observation, obtained in almost every instance by pains-taking effort.

Many others could be added to this list of difficulties, but all told, they are as mole-hills to mountains when compared with the fearful handicaps of the observing stations. Of the three or four used, it would be hard to say which was the worst. Viewed from all, the stars, those that did appear, shone like pale ghosts of themselves. It was a common practice to find and identify many fainter than the second magnitude by the tedious use of opera-glasses. Twilight, moonlight, haze, or a few clouds could easily reduce the whole heavens to a blank.

On the ground there was, of course, no horizon. Walls shut us in on every side, the glare of street lamps was in our eyes, and by the very irony of fate, there in the midst of New York City, fine, old trees, the pride of the college, obstructed the view over-head! The roof adjoining the classroom, after heat and lights were obtained, had the advantage of being near desks for writing and the many other accessories essential in observing. But little else can be said in its favor. One of the main walls of the building shut off the sky in the east, and the north was hardly better. The pole star was visible, low over a part of the roof, but its light was so faint and uncertain that often it seemed to fade away into the surrounding sky, when the pointer of an alt-azimuth was turned upon it. Conditions in the south and west are best indicated by noting that Fomalhaut barely came above the horizon when on the meridian, and that it was usual to point out one of the brightest stars in Orion as "that dim object just seen through the smoke of the chimney across the street." A prison might be a worse place, but having taught astronomy in the heart of New York, I am ready to qualify as a teacher of the science from the window of a prison cell!

And all over our country are schools and colleges, beautiful for situation, above whose roofs and towers bends the kindest of skies, where moon, planets and stars shine undimmed, and no one cares to study them.

The story of city astronomy is, however, only half told. In spite of everything, its case is not hopeless. Difficulties may be stepping-stones to victories. It is exhilarating to challenge the impossible. There are impossibilities, but many things masquerade under the title, without half deserving it. Astronomy based on direct observation of the heavens can be taught pleasantly and successfully in the city. Standards set for favorable localities need not be essentially modified. The seven fundamental topics for beginners can all be mastered. Naturally there will be some differences in apportioning time and effort. Special emphasis should be placed on subjects connected with the brightest heavenly bodies, the sun and moon, which are least affected by unfavorable conditions of the sky.

While telescopic observations, wherever elementary astronomy is taught, should hold only minor place, they may well come early in

order of time, in the city, and receive a little extra attention. Let the city do its worst, the sun still shines, and often there are days, poor astronomically, which can be utilized, with telescope and low-power eye-piece, in finding out the simple, first things about the solar surface. Sometimes, too, a break in the clouds makes it possible to examine the moon, when almost nothing else can be done. And only those who have tried, time and again, to see and identify the stars of a constellation at the very limit of visibility, can realize the comfort and satisfaction felt in sitting down at a small telescope with the moon in the field, and "seas," craters and mountain chains plainly in sight.

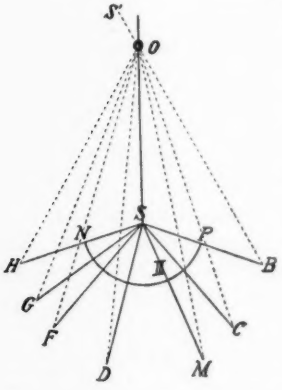
Far more essential than these are observations of the moon which determine its daily rate of motion and its monthly course about the celestial sphere; and those of the sun which provide data for locating its ever-changing diurnal path and finding latitude and time; for the sun in high heaven may be requisitioned to give help in ascertaining the errors of watches and the position of the school building in reference to the equator. No topics are more important for beginners than the last two, which are so intimately connected with every day life. In dealing with them, about the best mechanical aids are an open-style sundial* and a window gnomon.

Any one glancing into our New York classroom will see these instruments occupying most of the space in our laboratory corner. To economize room and facilitate adjusting and readjusting, the base of the sundial is made in the form of a half, instead of a whole, circle. The style, which is a long narrow ruler, has a slot throughout nearly its whole length, and so readings are taken, not from a shadow, as with most sundials, but from a shaft of sunlight. This use of light instead of shadow also characterizes the window gnomon. It has, properly speaking, no upright shaft, and the "perfectly horizontal plane" which usually receives the shadow is supplied in our instrument by the large projecting board, placed at right angles to the window. Any vertical line in the window, therefore, may serve as a gnomon shaft. No lines are actually drawn, but small pieces of dark paper with nearly circular apertures are pasted on the glass, and the center of any aperture is taken as the upper extremity of a shaft. Light coming through the aperture forms an image of the sun on the board below, whose center corresponds to the end of the shadow in the common gnomon. These and other points are illustrated by the diagram on the following page.

Here *O* represents one of the apertures mentioned, *OS* the gnomon shaft, *SM* the meridian line drawn through its foot, and *BCMDFGH*, points fixing the center of the sun's image at particular times. The

* See the writer's "First Observations in Astronomy," §§ 13, 79; 5, 31, 43, 44, 61.

different altitudes of the sun at these times are all obtained in the same manner, but special interest attaches to the meridian altitude, since that, combined with the sun's noon declination for the date, gives the latitude of the place. As seen from the diagram, when the sun's image is on the meridian at *M*, the line *MO* marks the direction of the sun, that is, *OMS* is its angle of elevation above the horizon, an angle easily calculated, as the triangle is right-angled at *S*. If preferred, however, a paper form of this triangle may be cut out, and the required angle read from a protractor.



Any observation for latitude has a double value, for it fixes the most important point in the sun's path for the day, the point where it crosses the meridian. To locate other positions in the path, both altitude and azimuth are required. The former, in every instance, is obtained as just described, since all the triangles with base lines passing through *S* are right-angled at that point. Azimuths are read from a protractor. Thus, in the diagram, *S P III N* represents a semi-circular protractor of paper, laid on the projecting board with its center at *S* and the line of zero degrees, *SIII* coinciding with the meridian *SM*. The azimuth of any position of the sun, as that when *F* was marked, is found by passing a straight edge through *S* and *F* and taking the reading where it intersects the graduated arc of the protractor. While it is true that paths determined in this way, have no points near either horizon, they meet the main ends for which all diurnal paths are observed. They show, when properly distributed through the year, the relation between different paths and changing seasons; and they provide a definite basis of fact for connecting intelligently the apparent motion of the sun with the real motion of the earth.

Under the most favorable conditions, it would be an unwise expenditure of time to trace the path of the sun from the eastern to the western horizon, and even that laborious operation would not give a complete diurnal path, for there is, of course, the section traversed below the horizon. Students, as well as astronomers, must make use of imagination and reasoning, and find means to deal with that which lies beyond what is actually seen. All observations of diurnal paths should be supplemented by many illustrations with the celestial globe.

Though mentioned last, observations for time are about the most important taken with the window gnomon. They are as simple as the

others. Thus, let the instant be noted by a watch, when the solar image formed by *O* is bisected by the meridian *SM*, and it should be, quite closely, the watch time of sun noon, for the vertical plane of the meridian *SM* passes as nearly as possible through the center of *O*. The reductions required to show how much the watch is fast or slow are made just as when any apparent time has been observed.

Since, then, the window gnomon facilitates three of the seven essentials for astronomical beginners, it may well have an important place. It is in front of the window gnomon, on bright days, when sun noon draws near, that our students stand, lined up in rows three or four deep. Those who have appointments for time come first. For example, at the western meridian, over which two plumb lines are suspended, there is one student who looks at the sun through dark spectacles and notes the transit of the first limb, center and second limb over the lines seen as one. A second student, taking care not to interfere with the first, employs the same meridian line, but looks down on the board, watching the image of the sun till it is bisected. Similar observations are carried on at the other meridians, but the instant they are finished, the first rows move quickly aside, the third and fourth come forward, and each individual puts a pencil dot at the center of the sun's image, near the meridian line to be employed. Experience shows that the error in latitude caused by observing, not exactly at sun noon, but a few minutes later is small compared with accidental errors which are always to be expected.

To fix the center of a circle of light is certainly easier than to locate the middle or the end of a shadow, and it is found practicable with classes made up of thirty or more inexperienced students, few of whom can be given a second trial, to set the limit of error for time within thirty seconds, and for latitude within half a degree. Often errors are ten seconds or less, and inside a quarter of a degree.

Doubtless it is partly due to the solar-image gnomon that our city students have been able to compete with those who work under good skies.

(*To be continued.*)

THE MOON.

MARIAN W. McFADDEN AND IRENE L. WINGARD.

What mysteries the moon must have presented to men of old! The waxing and waning phases must have excited their curiosity, because they were unacquainted with even the simplest phenomenon that dealt with the moon. Can you imagine what their feelings must have been, if during the short period of one month, for a few days they did not see the moon, then sometimes they would see a part of it, and at other times a full round and beautiful object in the sky? The moon thus became a measurement of time for the ancient people, and it is from the moon's period around the earth that our month was originated. It is not curious then that these people should have regarded the moon with amazement and have certain superstitions regarding it. In ancient times it was an object of worship, and in northern Europe, the wandering moon was looked upon as a bad omen. The best season for commencing any enterprise was during the period of the new or full moon. A superstition, which held wide sway, was that any operation which was designed to cause increase should be performed at the time of new moon, such as planting potatoes or cutting hair. On the other hand all enterprises desired to shrink should be performed at the time of full moon. There were also definite periods of the moon for attempting the cure of certain diseases and taking certain medicines. Some people today believe that if the horns of the moon are tilted towards the earth, it is a sign of rain, and when tilted away is a sign of dry weather. That is, when the moon is low in the sky at sunset the horns tilted towards earth give us rain, but when it is high in the sky at sunset and lies on its back, rain is not permitted to come out of it to the earth. But this position of the horns is due to the position of the moon in reference to the sun. The horns of the moon always point away from the sun. Maybe the way this superstition started was that the horns happened to be tilted when it rained. By observing the weather for ourselves we notice that usually we have the same kind of weather only for a few days at a time. Therefore almost any guess concerning wet or dry weather might easily be right. At the present time the moon is used by navigators, on long voyages, in finding out the position of ships.

The moon, not being a self-luminous body like the sun, shines only by reflected light, that is, it receives light from the sun and reflects it to the earth. It is said that to equal the brilliance of the sun

over half a million moons would be required. The moon when it is low in the sky seems much larger to the naked eye than when it is high in the sky. This is due to the fact that when the moon is low we compare it with the large houses and trees, which seem to be near it; but, when it has risen high in the sky, there is nothing with which we can compare it, therefore the moon seems much smaller.

The appearance of the moon to the naked eye is most interesting. Portions of it are very bright while others are so shaded that they present to the eye the outline of a human face, which gives rise to the legend of the "man in the moon," a human figure supposed by the French to be Judas Iscariot, who they said was sent to the moon as a punishment. When the moon is several days old, we see a bright crescent, which is completely illumined, with a faint light revealing the dark hemisphere. When it is in this condition we say that "The old moon is in the new moon's arms." This condition is due to the fact that the light falls from the sun to the earth and is then reflected to the moon. The surface of the moon, as seen from the earth, shows an irregular grouping of light and shade. The bright parts are mountains, this having been proved by the fact of their casting shadows, when the rays of the sun fall on them obliquely. The small features on the moon are named for eminent philosophers and astronomers. The dark regions we call oceans and all have very fancy names, such as Oceanus Procellarum, etc.

In viewing the moon through the telescope the markings almost vanish and are replaced by a great number of smaller markings. The best time to look at the moon through the telescope is when it is between six and ten days old, or even up to fourteen days. It is an interesting fact to know that when the moon is half full its illumined and visible area, measuring from horn to horn, is about equal to the United States. The distance from one horn to the other is 3,396 miles and the distance from Maine to California is 3,100 miles. Through the telescope the moon presents a desolate appearance; it seems to have neither animal nor vegetable life upon it because there is neither water nor air. Even though there was once water on the moon, when the moon lost its blanket of atmosphere, the water must have evaporated speedily under the sun's direct rays. Early observers thought that the dark places on the moon were seas and named them as oceans, which names are used today. There are also a great many mountains on the surface of the moon. The broken and irregular character of the surface is most evident near the boundary between the dark and illumined portions near the first quarter. Several bright spots are visible by earth light on the moon when it is a crescent, and Herschel thought that these were volcanoes in eruption. The telescope showed these to be

nothing but spots of unusual brightness. Several of these spots change, but this is thought to be due to the simple reason that the light from the sun in its different phases of illumination strikes these regions from various directions.

Thus, one may see that the moon is a very interesting object in the sky and it can be studied with interest both with the naked eye and with the aid of the telescope. The moon in ancient times was studied for the part it played in superstition; but at the present it is studied for the knowledge it gives us of the heavenly bodies.

DONATI'S COMET AND OTHER COMETS.

CHARLES NEVERS HOLMES.

Spectres of the sky! Wandering phantoms of the darkened firmament! Occasionally visible to the unassisted eye of man; mostly invisible except through the telescope. Myriads of them, and then myriads more, in our Universe—our so-called local Universe. Our earth revolving swiftly around King Sol comes occasionally in sight of some comet—larger or smaller—that slowly approaches and slowly departs. It comes and goes, faintly, brightly, and then again faintly, and fades at last even from telescopic sight. It may return once more, sooner, or later; it may never return. It may reappear within a few years, within a few centuries, within thousands of years; and it may vanish for ever, either because it has wholly left the influence of our solar system or because it is destroyed by some unknown cause.

Comets!—spectres of the star-lit firmament! For many centuries their appearance has been recorded, their coming and going have been handed down to us. In pre-historic times these spectres of the sky must have filled the minds of the then terrestrial inhabitants with awe and even fear. Ignorant of the cause of such a celestial visitor, the pre-historic star-gazer must ofttimes have worshiped it or considered its slow approach as a harbinger of some direful happening. As the eras of such pre-historic times passed away, men began to make records of some of these sky spectres, of some of those which were most spectacular and noticeable. But it was not until comparatively recent times—until after the days of Galileo and his telescope—that man was able to understand very much respecting these phenomena of the darkened firmament.

However, after the year, 1000 A. D., we can rely with more certainty upon accounts of the appearance of remarkable comets. Such comets were reported in 1066, 1106, 1145, 1265, 1378, 1402, 1456, 1531, 1556, 1577, 1607, 1618, 1661, 1680, 1682, 1689, 1729, 1744, 1759, and 1769. Of course, such comets must have been particularly noticeable for their records to have come down to us. But although these pre-19th century comets are of much interest to us of this 20th century, we are more interested in comets like Donati's, which appeared after the beginning of the 19th century. The first of these later sky-spectres was the very remarkable one that visited us in 1811, which was discovered by Flaugergues at Viviers, on March 26, and was last seen by Wisniewski at Neu-Techerkask, August 17, 1812. Thus, it will be seen that this comet remained in sight for nearly one and a half years. Its nucleus (or concentrated point of light in coma or head) was well-defined, being some 428 miles in diameter; its coma or head was estimated at 108000 miles diameter, while its tail had an extreme length of 25 degrees with a breadth of 6 degrees, being calculated at approximately 108,000,000 miles. Although neither we nor our children's children for many, many generations will again see this remarkable comet, it is, nevertheless, what is known as a "periodical one", that is, it will return—provided it be not destroyed—after some 3000 years. Of course, during those 30 centuries, the so-called comet of 1811 must wander a vast distance from our earth. This distance has been estimated as about 14 times as far as it is to the planet Neptune, that is, that the comet of 1811 at its aphelion distance is some 40,000,000,000 miles away.

In 1823 there was a remarkable comet, and another visited us in 1835-36 (Halley's). In 1843, a still more remarkable comet came in sight, one that was very bright and caused considerable alarm in the minds of less educated people. This comet was first observed in the southern hemisphere, towards the end of February, and shone most brightly during the first fortnight in March. Its tail was very long, some 40 degrees, with a breadth of 1 degree. In other words, it is estimated that its tail approximated a length of 200,000,000 miles. It is, however, owing to the fact that this comet approached so closely to the powerful attraction of fiery King Sol, that makes it so remarkable. Its closest distance to the solar surface was variously estimated, as near as half-a-million miles according to one calculation; but this venturesome visitor escaped without destruction, although, as may be supposed, its velocity at perihelion—when nearest to the sun—was terrific.

The next remarkable sky-spectre to be considered is that of the year 1858. This comet is the one known as "Donati's", being discovered by

Dr. G. B. Donati at Florence, on June 2, 1858. At that time it was merely a telescopic object, a dim nebulosity not far from the sun Lambda in the constellation of Leo. The comet was then some 240,000,000 miles from our earth, and did not become visible to unassisted eyesight until near the end of August. On the 14th-20th of August the first traces of a tail were observed, and the brightness and velocity of the comet steadily increased. On September 6, a slight curvature of the tail was noticed; on the 12th, there was a sudden increase in lustre; and, on September 17, the coma or head was equal in brightness to a star of second magnitude—such a sun as the Pole-Star, for example. On September 29, this comet reached perihelion, and, on October 10, it was at its least distance from our earth.

The nucleus of the comet of 1858 was well-defined, varying in diameter from 500 to 3000 miles. Its tail was long and remarkably beautiful, and after perihelion, as the comet was leaving the Sun, this tail, which was of a plumed appearance, displayed its full length and splendor for the first time. The extreme length of this tail approximated 50 degrees, with a breadth of 5 or 6 degrees. In popular dimensions, the tail was some 45,000,000 miles long, with a width of about 10,000,000 miles. On October 2, the nucleus shone more brightly than did the great sun Arcturus which was in the same part of the firmament; and for a week or so this remarkable comet was a most noticeable sky-object a half-hour after sunset. The comet remained in sight—of the unassisted eye—for about 112 days, and was telescopically visible for 275 days, the last observation respecting it being made at the Cape of Good Hope, March 4, 1859. Like the great comet of 1811, the greater comet of 1858 will not be seen again for a long time, although the period of the comet of 1858 is about 2000 years, instead of 3000, and it will be seen by the eyes of far future generations—provided it be not in the meantime destroyed—about the year 4000 A.D. Its pathway through space may be described as a vast, elongated ellipse; with an aphelion perhaps 5½ times as far as from the Sun to Neptune, and a perihelion within the orbit of the planet Venus.

Donati's comet appeared, shone brightly and beautifully, and then disappeared; and then another, though less remarkable comet, that of 1861, occupied for a while man's celestial attention. This comet of 1861 was discovered by Mr. J. Tebbutt, an amateur astronomer of New South Wales, on the 13th of May, its perihelion occurring on June 11. This particular comet is chiefly interesting because of the certainty that our earth passed through a portion of its tail. Indeed, it was estimated that our planet became immersed in that tail to the depth of some 300,000 miles, remaining within the comet for several hours. However, the astronomical proof that we passed through the tail of

this comet, on June 30, 1861, is based wholly upon mathematics and theory. Nothing out of the ordinary was observed in the sky or on the land. There were not even any unusual electrical phenomena. But it is certain that this tail was of great dimensions, its extreme length being announced as 118 degrees, The orbit of this comet of 1861 is also a long one, and its period has been computed at about 409½ years.

Since the comet of 1861, there have, of course, been a number of remarkable or noticeable sky spectres, as those of 1874, 1882, and 1901. The comet of 1882 was particularly remarkable and beautiful, and was associated with a considerable variety of cometary phenomena. It was discovered by a person whose name is not known, in New Zealand, on the 3rd of September, and became on the 7th and 8th rather conspicuous. The comet of 1882 remained in sight for a period of about nine months, and after its disappearance no comet as remarkable was seen until some 20 years later. However, in 1901, a very remarkable comet suddenly appeared, on April 24th. This comet was discovered by several persons, observing independently. It possessed two tails, the main one being some seven degrees in length, while a sort of secondary tail was followed for a firmamental distance of about 25 degrees.

In 1902, there appeared Perrine's comet which proved very disappointing, and we all can remember our recent dissatisfaction over the much-advertised reappearance of the famous Halley's comet. Indeed, its reappearance was so recent that we are still well acquainted with its history. Of course we know that this was the first comet to have its return predicted, and that Edmund Halley (1656-1742) was the astronomer to accomplish this prediction. Halley based his prediction upon the fact that he had found the orbit of this comet in 1682 to be almost identical with those of the comets of 1531 and 1607, comets which had been carefully observed by Kepler and Apian, and he also compared his comet with the records of comets appearing in 1066, 1145, 1301, and 1456. Accordingly, he soon had the confidence to announce that the comet of 1682 would reappear some 75 years later, which proved to be the case, and Halley's comet has been a popular one ever since, usually being very faithful and rather spectacular, although its last return in 1910 was somewhat disappointing. Halley's comet, although it has a period of about 75 years, may, comparatively speaking, be called a "short period" comet, for some of these firmamental spectres—as we have seen—possess periods of thousands of years. There is a well known list of these short period comets, and, despite the fact that it is so well known, it should be inserted at this point. It is as follows:

(1) Encke's comet	3.3 years	(8) Wolf's comet	6.7 years
(2) Tempel's II	5.2	(9) Finlay's	6.7
(3) Barnard's	5.4	(10) Faye's	7.6
(4) Brorsen's	5.5	(11) Tuttle's	13.8
(5) Winnecke's	5.8	(12) Pons-Brooks	71.5
(6) Tempel's I	6.5	(13) Olber's	72.6
(7) D'Arrest's	6.7	(14) Halley's	74.4

At the head of this list is the famous Encke's comet, which, as is evident, has the shortest time or period of any comet—about 3⅓ years. This comet was observed in 1786, 1795, and 1805; but Encke was the first astronomer to discover its periodicity, in 1819. In that year, he announced that the comet would return to perihelion on May 24, 1822, and his prediction was most satisfactorily fulfilled. Afterwards, Encke also announced that this comet would reappear in 1825, 1829, 1832, 1835 or, in other words, that it had a period of 3.3 years. Encke's comet, is not, unfortunately, usually visible to the naked eye, a telescope being necessary, as a rule, to observe it. It is not, therefore, like Halley's comet, a popular astronomical object.

The second in the above list is named "Temple's II," being discovered by that astronomer at Milan, on July 3, 1873. Its next return was announced for August, 1878, and it was seen at the Oxford Observatory (through a 12-inch refractor) with much difficulty. As will be found in the table above, Temple's II should visit us once in about every five years.

Numbers 3, 4 and 5 on the list are named respectively Barnard's, Brorsen's and Winnecke's. The last of these three—Winnecke's—was discovered by M. Pons, on June 12, 1819. However, the comet was not again seen after 1819 until it was rediscovered by Winnecke at Bonn, in 1858, who thought he had found a "new comet". Thus, the comet came to be called by his name. With respect to numbers 3 and 4, the former was discovered by Mr. E. E. Barnard at Nashville, Tennessee, July 16, 1884, while the latter was first seen by Brorsen at Kiel, on February 26, 1846.

Some of the other comets on this list were discovered respectively by Temple at Milan, April 3, 1867; by D'Arrest at Leipzig, June 27, 1851; by Wolf, on September 17, 1884; by Finlay, September 26, 1886; Faye, November 22, 1843; and by Tuttle, at Harvard College Observatory, on January 4, 1858. As is to be seen, the comets from Encke's to Tuttle's are predicted to appear once in from 3 1/3 to 13 4/5 years, while the comets from Pons-Brooks' to Halley's should appear once in about 71 1/2 to 74 4/10 years. As we all know, Halley's comet will not visit us again for some seventy years; but both Pons's and Olbers's will come before that time, the former being due around 1954 and the latter around 1961. Of course, as is very evident, a comet may not always arrive on scheduled time, owing to divers planetary attractions—

it may be late; and one or more in the above list may never be seen again. A comet may disappear completely as a comet, just as Biela's comet has not been seen since 1852.

Something here should be written concerning this lost comet. It was formerly in the list of short period comets, being discovered by Biela, an Austrian officer, at Josephstadt, Bohemia, on February 27, 1826. Previous to this discovery by Biela, it is believed to have been seen by Montaigne at Limoges, March 8, 1772, and by Pons on November 10, 1805. It was the second comet of short period in order of its discovery; and its history is both interesting and tragical. After its appearance in 1826, it reappeared in 1832. On this reappearance in 1832, owing to the fact that its orbit passed rather close to our earth's, a report spread that there would be a collision between this sky spectre and our planet, a report that caused the first of the popular "comet scares". In 1839, the comet was too near the sun to be observed, and when it reappeared in 1846 the comet was divided into two parts. In 1852, this divided comet again visited us, being seen last in August; but from that time to this Biela's comet, as such, has never been found.

However, it is believed that this comet in a scattered and destroyed condition still exists. Its period was 6.6 years, and, on the night of November 27, 1872, as our earth was passing the former track of the lost comet, there occurred a splendid meteoric shower. Another splendid meteoric display took place in November, 1885, when our planet was again crossing the former pathway of Biela's comet, and the theory was discussed whether or not these displays of "shooting-stars" were due to the collision of our earth's atmosphere with portions of the former comet. Such a theory seems very probable, for the tiny particles that once composed the comet could cause such displays, and the comet, even if wrecked, would still be drifting like a derelict, a harmless derelict; through the broken fragments of which, at times, our earth would rush in its annual revolution around the sun.

But Biela's comet must be only one of many such wrecked comets, and, as certain of these sky spectres vanish forever from man's sight others will come to take their places. Besides the comets whose returns can be more or less certainly predicted, new comets are every few years observed by the powerful eye of the telescope, as these sky spectres are captured during the progress of the solar system through the ocean of ether or as some comet of long period returns to perihelion. Before the Christian era, records were made of some 80 comets, while since the beginning of that era there has been an approximation of a thousand of such records. There is a constant, though uncertain, appearance and disappearance of these spectres of the darkened firmament, and at any time a comet equalling or surpassing that of 1811 or

of 1858 may shine brightly and spectacularly upon our terrestrial home. But we no longer fear these spectres from the standpoint of superstition and ignorance. We admire and welcome them gladly as they shine so splendidly and seemingly portentous amid the star-lighted dome of night. Like man's own terrestrial life, they come and go; they appear and disappear, leaving as little trace of their former presence as a foot-print washed away by the rising tide. Nevertheless, the recollection of their firmamental splendor still lingers with us. The comet of 1811, of 1843, of 1858, 1861, 1882, and 1901 will not soon be forgotten. Donati's comet and other comets may not have been seen by this generation; but we read and reflect upon the remarkable comets of yesterday, admire and study the comets of today, and wait in eager hope for some even more remarkable comet of tomorrow.

Hotel Nottingham,
Boston, Mass.

PLANET NOTES FOR APRIL, 1915.

The sun will move northeasterly from the constellation Pisces into the constellation Aries during this month. At the close of the month it will be in the region of the sky near the Pleiades. It will not pass near any very bright star in its course.

The phases of the moon for this month are as follows:

Last Quarter	Apr.	6	at	2 P.M.	C.S.T.
New Moon		14	"	6 A.M.	"
First Quarter		22	"	10 A.M.	"
Full Moon		29	"	8 A.M.	"

Mercury will just be visible in the eastern sky just before sunrise at the beginning of the month. It will be moving rapidly eastward toward the sun, and will soon become invisible because of its nearness to the sun. It will be about ten degrees south of the sun, which is unfavorable. It will be back of the sun on the first of May.

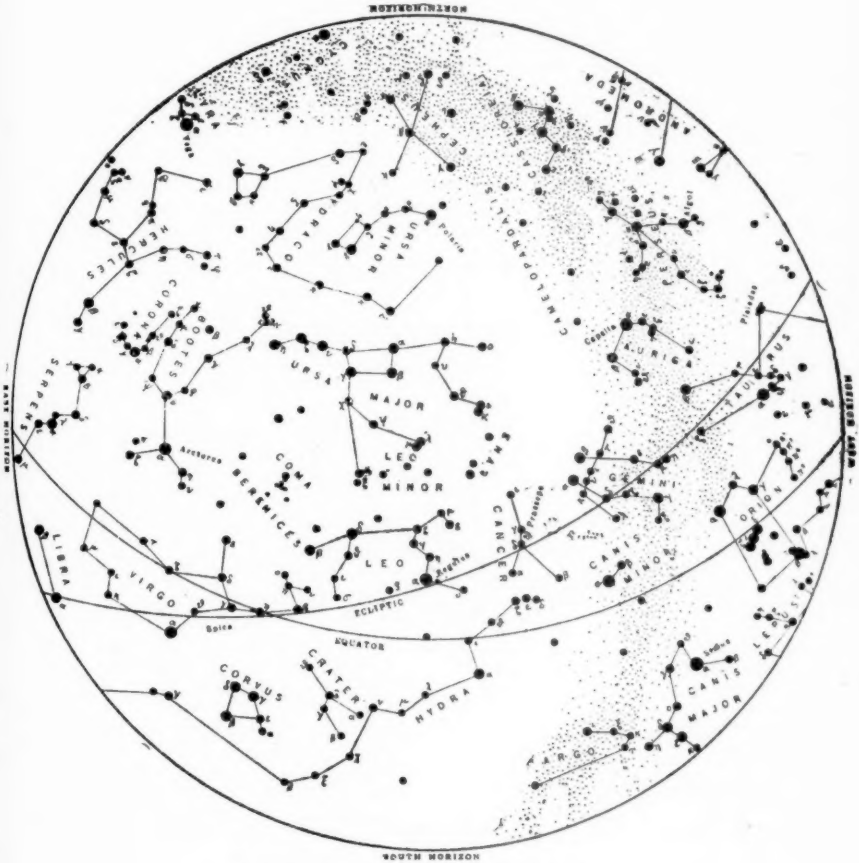
Venus, as seen from the earth, will move eastward at nearly the same rate as the sun. It will cross the meridian about two and a half hours before the sun throughout the month. Consequently it will rise before the sun, although not quite two and a half hours because it will be nearly fifteen degrees south of the sun. It will, however, be easily visible in the morning sky. It will be four or five times as bright as Sirius. With good eyesight, if one knows its exact position, it may be seen even after sunrise.

Mars, which has been moving eastward along with the sun for several months, will be lagging behind the sun far enough to become visible about two hours before sunrise this month. It is approaching the earth and therefore becoming brighter. It is however still so far away as to be comparatively faint.

Jupiter will be rather near Mars during this month. It will therefore also be a morning star. It will be interesting at the beginning of the month to see Mercury,

Venus, Mars and Jupiter all in the eastern sky at sunrise. Jupiter, however, will not be far enough from the sun to permit of satisfactory observation.

Saturn will still be an interesting object for observation in the evening. It will cross the meridian in the afternoon and therefore be in the western sky after sunset. It will be high enough still to be in very favorable position.



THE CONSTELLATIONS AT 9:00 P. M. APRIL 1.

Uranus will be visible in the early morning. It will be well up in the sky at sunrise.

Neptune will still be favorably situated during this month. It will cross t he meridian a little before sunset and therefore may be observed in the evening.

Occultations Visible at Washington.

Date 1915	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle f'm N.	EMERSION. Washington M.T.	EMERSION. Angle f'm N.	Duration
			h m	°	h m	°	h m
Apr. 21	82 Geminorum	6.3	7 42	157	8 43	256	1 1
22	102 B Cancri	6.5	7 10	100	8 26	324	1 16
22	ϵ Cancri	6.3	7 20	121	8 41	302	1 21
30	π Scorpii	3.0	8 24	102	9 21	301	0 57

Saturn's Satellites for April 1915.

CENTRAL STANDARD TIME.

E = eastern elongation; W = western elongation;
I = inferior conjunction; S = superior conjunction.

I. Mimas. Period $0^d\ 22^h.6$

II. Enceladus. Period $1^d\ 8^h.8$

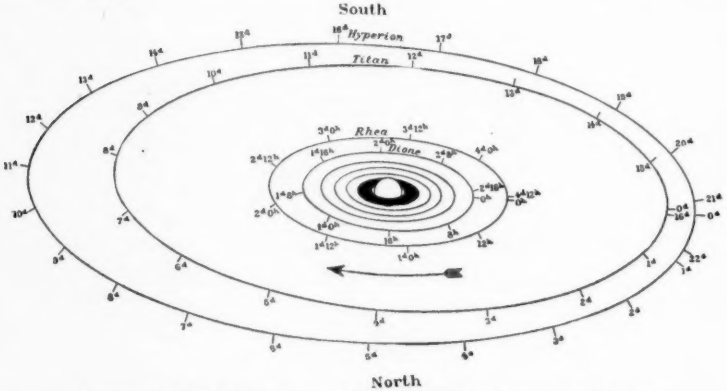
Apr. 1	h 16.7 E	Apr. 4	h 10.5 E	Apr. 7	h 4.3 E	Apr. 8	h 13.1 E
3	1.6 E	5	19.4 E				

III. Tethys. Period $1^d\ 21^h.3$

Apr. 1	18.8 E	Apr. 5	13.5 E	Apr. 9	8.1 E	Apr. 13	2.8 E
3	16.1E	7	10.8 E	11	5.5 E	15	0.1 E

IV. Dione. Period $2^d\ 17^h.7$

Apr. 1	7.6 E	Apr. 6	19.0 E	Apr. 9	12.8 E	Apr. 12	6.5 E
4	1.3 E						



Apparent Orbits of the Seven Inner Satellites of Saturn, at date of Opposition, December 20, 1914, as seen in an Inverting Telescope.

V. Rhea. Period $4^d\ 12^h.5$

Apr. 2 20.0 E

VI. Titan. Period $15^d\ 23^h.3$

VII. Hyperion. Period $21^d\ 7^h.6$

Apr. $1^d.7$ S	Apr. $6^d.4$ E	Apr. $11^d.3$ I	Apr. $17^d.2$ W

VIII. Japetus. Period $79^d\ 22^h.1$

Apr. $9^d.4$ E

IX. Phoebe. Period $580^d\ 2^h.9$

	α Ph.–α Sat.	δ Ph.–δ Sat.	α Ph.–α Sat.	δ Ph.–δ Sat.
	m s	′ ″	m s	′ ″
Apr. 3	−1 11.2	−3 11	Apr. 19 −0 41.8	−2 36
7	1 4.1	3 2	23 0 34.1	2 27
11	0 56.8	2 54	27 −0 26.3	−2 19
15	−0 49.4	−2 45		

VARIABLE STARS.

Approximate Magnitudes of Variable Stars of Long Period on Feb. 1, 1915.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900	Decl. 1900	Magn.
	h m	° ′			h m	° ′	
T Androm.	0 17.2	+26 26	8.6	X Monoc.	6 52.4	− 8 56	7.4
T Cassiop.	17.8	+55 14	9.4*d*	R Lyncis	53.0	+55 28	9.0 *i*
R Androm.	18.8	+38 1	8.4 *i*	R Gemin.	7 1.3	+22 52	10.4*d*
S Ceti	19.0	− 9 53	8.0	R Can. Min.	3.2	+10 11	10.0*d*
U Cassiop.	40.8	+47 43	8.4 *i*	S Can. Min.	27.3	+ 8 32	7.4
V Androm.	44.6	+35 6	<11.0	U Can. Min.	35.9	+ 8 37	9.6*d*
RR Androm.	45.9	+33 50	10.7*d*	S Gemin.	37.0	+23 41	12.1*d*
W Cassiop.	49.0	+58 1	9.3 *i*	T Gemin.	43.3	+23 59	9.3*d*
S Piscium	1 12.4	+ 8 24	12.4*d*	S Hydrae	8 48.4	+ 3 27	10.4 *i*
R Piscium	25.5	+ 2 22	10.1*d*	R Leo. Min.	9 39.6	+34 58	7.6
X Cassiop.	49.8	+58 46	10.0	R Leonis	42.2	+11 54	6.6
U Persei	53.0	+54 20	8.0*d*	R Urs. Maj.	10 37.6	+69 18	7.8 *i*
R Arietis	2 10.4	+24 35	9.6 *i*	T Urs. Maj.	12 31.8	+60 2	8.1*d*
o Ceti	14.3	− 3 26	3.5 *i*	R Virginis	33.4	+ 7 32	11.0
U Ceti	28.9	−13 35	8.3 *i*	S Urs. Maj.	39.6	+61 38	10.7*d*
R Trianguli	31.0	+33 50	10.8*d*	R Can. Ven.	13 44.6	+40 2	8.1 *i*
W Persei	43.2	+56 34	11.2	U Urs. Min.	14 15.1	+67 15	8.5
U Arietis	3 5.5	+14 25	10.2 *i*	R Camelop.	25.1	+84 17	9.3*d*
Y Persei	20.9	+43 50	8.6	V Bootis	25.7	+39 18	7.4
V Eridani	59.8	−16 0	8.6	S Cor. Bor.	15 17.3	+31 44	7.0
W Tauri	4 22.2	+15 49	12.5	S Urs. Min.	33.4	+78 58	11.8*d*
R Tauri	22.8	+ 9 56	<13.0	R Draconis	16 32.4	+66 58	8.6*d*
S Tauri	23.7	+ 9 44	<13.0	W Lyrae	18 11.5	+36 38	8.5*d*
X Camelop.	32.6	+74 56	8.0	R Cygni	19 34.1	+49 58	11.5 *i*
RX Tauri	32.8	+ 8 9	9.0	RT Cygni	40.8	+48 32	11.8
V Tauri	46.2	+17 22	8.9	χ Cygni	46.7	+32 40	6.3*d*
R Leporis	55.0	−14 57	9.0	Z Cygni	58.6	+49 46	<11.0
V Orionis	5 0.8	+ 3 58	<10.0	U Cygni	20 16.5	+47 35	8.4*d*
R Aurigae	9.2	+53 28	8.5 *i*	T Cephei	21 8.2	+68 5	7.6*d*
W Aurigae	20.1	+36 49	11.7*d*	RU Cygni	37.3	+53 52	9.7*d*
U Orionis	49.9	+20 10	11.6	R Pegasi	23 1.6	+10 0	9.4*d*
Z Aurigae	53.6	+53 18	9.0	V Cassiop.	7.4	+59 8	8.8 *i*
X Aurigae	6 4.4	+50 15	8.3	ST Androm.	33.8	+35 13	11.0
S Lyncis	35.9	+58 0	11.8 *i*	R Aquarii	38.6	−15 50	10.5*d*
X Gemin.	40.7	+30 23	8.4	R Cassiop.	53.3	+50 50	8.9*d*

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—L. Barbour, T. C. H. Bouton, A. B. Burbeck, H. O. Eaton, F. H. Hay, S. C. Hunter, C. B. Lindsley, O. Mach, C. Y. McAteer, C. S. Mundt, W. T. Olcott, D. B. Pickering, C. Richter, F. H. Spinney, H. M. Swartz, H. W. Vrooman, I. E Woods, and A. S. Young.

The following stars are now growing faint and need observations with a large telescope:—

004533	RR Androm.	090425	W Cancri	201008	R Delphini
011208	S Piscium.	124204	RU Virginis	202954	ST Cygni
042215	W Tauri	161138	W Cor. Bor.	203611	Y Delphini
042209	R Tauri	163137	W Herculis	203847	V Cygni
042309	S Tauri	164715	S Herculis	204318	V Delphini
050003	V Orionis	175519	RY Herculis	210129	TW Cygni
052036	W Aurigae	184243	RW Lyrae	210382	X Cephei
053531	U Aurigae	192928	TY Cygni	231425	W Pegasi
070122a	R Gemin.	194604	X Aquilae	231508	S Pegasi
073723	S Gemin.	200212	SY Aquilae	235939	SV Androm.

Minima of Variable Stars of Short Period.

[Calculated by Elva Utzinger and C. D. Hibbard at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1915 April
	h m	° ′		d h	d h d h d h d h d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	2 2;
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	8 14; 16 6; 23 22
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	4 17; 12 3; 19 14; 27 0
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	6 1; 13 12; 21 0; 28 11
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	6 9; 12 12; 24 17; 30 20
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	2 15; 9 19; 16 22; 24 2
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	3 12; 10 9; 24 3; 30 23
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	4 4; 11 8; 18 12; 25 16
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	1 5; 9 23; 18 18; 27 13
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	5 1; 13 0; 20 23; 28 1
RX Cassiop.	58.8	+67 11	8.6— 9.1	32 07.6	25 10
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	1 20; 7 14; 19 1; 30 12
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	6 6; 13 1; 19 20; 26 15
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	1 16; 9 14; 17 11; 25 9
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	2 8; 10 15; 18 22; 27 6
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	7 4; 15 1; 22 22; 30 20
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	10 20; 24 1
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	9 10; 18 21; 28 7
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	5 6; 17 16; 30 2
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	3 21; 10 13; 23 21; 30 13
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	5 10; 10 21; 16 8; 27 6
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	5 10; 11 10; 23 11; 29 12
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	2 5; 10 21; 19 13; 28 5
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	8 8; 18 17; 29 2
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	5 20; 13 20; 21 21; 29 21
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	4 5; 9 22; 21 9; 27 3
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	2 5; 7 19; 19 0; 30 5
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	7 1; 15 5; 23 10;
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	5 3; 12 18; 20 9; 28 0
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	6 19; 19 0
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	2 16; 9 20; 17 0; 24 4
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	4 13; 13 15; 22 17
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	3 13; 12 21; 22 4
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	2 9; 12 7; 22 5
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	8 0; 16 10; 24 20
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	2 9; 8 19; 15 5; 28 2
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	3 20; 11 3; 18 10; 25 16
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	3 7; 11 9; 19 12; 27 15
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	7 19; 17 6; 26 18
RX Hydrae	9 0.8	− 7 52	9.1—10.5	2 6.8	2 17; 11 20; 20 23; 30 2
S Antliae	27.9	−28 11	6.3— 6.8	0 07.8	1 19; 8 6; 21 6; 27 17
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	4 19; 10 17; 22 14; 28 12
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	4 5; 12 15; 21 2; 29 12
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	5 20; 15 2; 24 9
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	2 9; 8 23; 22 4; 28 18
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	8 5; 17 0; 25 19
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	4 7; 11 15; 18 23; 26 6
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	6 10; 13 5; 20 0; 26 1
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	3 14; 11 2; 18 15; 26 3
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	6 9; 13 19; 21 5; 18 1 6
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	2 3; 9 3; 23 2; 30 2
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	5 18; 12 16; 19 13; 26 1 1 6
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	2 9; 10 20; 19 6; 27 1

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1915 April
	h m	° ′		d h	d h d h d h d h
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	8 3; 15 19; 23 11
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	4 13; 11 21; 19 5; 26 13
SX Ophiuchi	12.6	− 6 25	10.5—11.2	2 01.5	2 13; 10 19; 19 2; 27 8
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	4 2; 12 22; 21 19; 30 15
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	4 14; 14 6; 25 7
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	2 17; 9 13; 23 3; 29 22
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	6 17; 15 3; 23 12
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	1 5; 7 9; 19 16; 25 20
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	1 12; 8 17; 23 3; 30 8
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	6 7; 13 16; 21 1; 28 10
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	1 13; 9 17; 17 21; 26 2
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	2 5; 9 18; 17 7; 24 20
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	2 11; 10 5; 17 23; 25 17
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	8 17; 16 17; 24 17
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	7 0; 15 12; 24 1
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	4 11; 13 19; 23 3
SX Draconis	18 03.0	+ 58 23	9.3—10.5	5 04.1	8 0; 18 8; 28 16
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	8 3; 15 9; 22 15; 29 21
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	3 1; 9 23; 16 21; 30 16
RZ Scuti	21.1	− 9 15	7.4— 8.3	15 03.2	4 17; 19 21
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	3 6; 11 12; 19 19; 28 1
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	7 22; 16 19; 25 17
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	2 5; 10 13; 18 20; 27 3
RR Draconis	40.8	+62 34	9.3—13	2 19.9	5 20; 14 8; 22 20
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	4 21; 11 12; 18 4; 24 19
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	10 18; 23 17
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	10 10; 19 23; 28 12
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	5 23; 13 13; 21 3; 28 16
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	8 1; 15 6; 22 10; 29 15
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	9 9; 18 8; 27 7
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	7 13; 14 7; 21 1; 27 20
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	4 23; 12 8; 19 16; 27 1
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	4 1; 9 7; 20 19; 26 1
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	5 13; 12 1; 18 14; 25 2
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	3 1; 9 1; 15 1; 27 2
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	2 23; 9 15; 22 21; 29 12
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	6 16; 15 19; 24 23
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	1 2; 9 12; 17 22; 26 9
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	5 11; 12 6; 19 1; 25 19
UW Cygni	19.6	+42 55	10.5—13	3 10.8	2 19; 9 17; 16 14; 30 10
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	18 2
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	8 8; 17 22; 27 13
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	5 10; 14 15; 23 20
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	6 14; 14 2; 21 13; 29 1
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	6 4; 12 0; 23 17; 29 13
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	2 8; 12 10; 22 12
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	5 23; 13 8; 20 17; 28 2
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	1 4; 10 20; 20 13; 30 5
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	1 17; 9 14; 17 11; 25 8
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	7 21
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	3 4; 13 8; 23 11
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	3 8; 13 17; 24 2; 29 6
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.6	3 4; 14 2; 19 12; 30 10
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	3 17; 12 0; 20 7; 28 15
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	8 2; 15 15; 23 4; 30 17
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	3 8; 11 14; 19 20; 28 2

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes and Agnes E. Wells at Goodsell Observatory.]

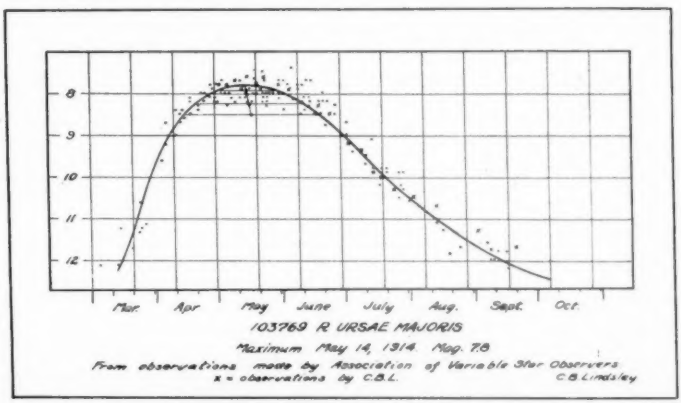
Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

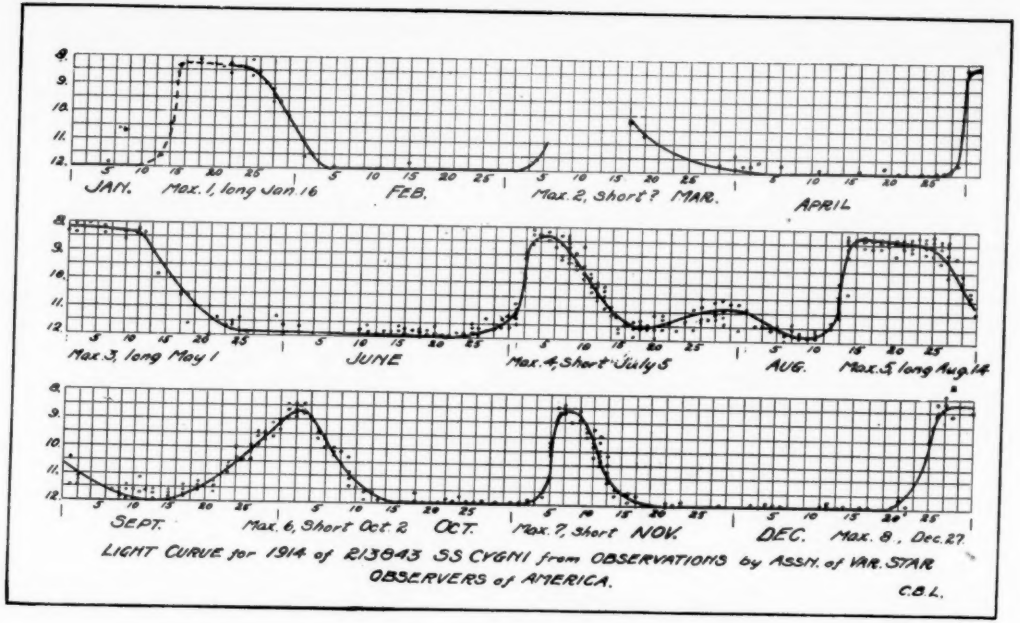
Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1915. April.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.4	36 13.7				29 23				
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	1 15;	9 18;	17 22;	26 1				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	1 13;	9 7;	17 0;	24 18				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2		11 17;	26 12					
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	3 12;	11 11;	19 9;	27 8				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	8 17;	16 12;	24 7					
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	1 0;	8 7;	22 21;	30 4				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	5	21						
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	3 4;	11 18;	20 8;	28 22				
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	2 15;	13 18;	24 22					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	6 7;	17 22;	29 13					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	7 0;	14 16;	22 8;	29 23				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	2 16;	12 19;	22 23					
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	3 17;	11 10;	19 3;	26 20				
RZ Gemin.	5 56.6	+22 12	9.1—10.0	5 12.7	2 16;	8 4;	19 6;	30 7				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	2 0;	9 14;	17 3;	24 17				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		12 14						
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	3 20;	11 1;	18 6;	25 11				
W Gemin.	6 29.2	+15 24	6.7— 7.5	7 22.0	8 14;	16 12;	24 10					
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 8;	13 12;	23 16					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		16 4						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	1 13;	9 12;	17 10;	25 9				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	2 10;	9 2;	22 12;	29 5				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	1 20;	11 2;	20 9;	29 16				
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	2 4;	10 22;	19 16.	28 9				
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 0.0		10						
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	4 13;	11 8;	18 3;	24 22				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	7 7;	13 21;	20 12;	27 2				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	3 15;	13 6;	22 22					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	2 21;	10 20;	18 19;	26 19				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	1 3;	7 20;	21 7;	28 1				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	2 3;	7 23;	19 14;	25 10				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	1 3;	5 20;	15 5;	24 14				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5		13 3;	30 10					
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	5 5;	13 10;	21 14;	29 19				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	4 13;	11 14;	18 14;	25 15				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	2 0;	10 5;	18 10;	26 15				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	2 21;	8 9;	19 9;	30 8				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	2 5;	9 18;	17 7;	24 20				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	5 17;	13 3;	20 13;	27 23				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	5 17;	12 12;	19 6;	26 1				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	6 1;	12 9;	18 17;	25 1				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1		10 3;	19 21;	29 15				
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6		8 10;	17 7;	26 4				
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	3 3;	9 5;	21 8;	27 9				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	6 8;	13 8;	20 9;	27 9				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9	5 3;	22 6						
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	2 10;	10 1;	17 15;	25 5				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	4 11;	10 5;	16 0;	27 13				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	5 22;	12 16;	19 10;	26 3				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	2 14;	12 22;	23 6					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	4 3;	10 4;	22 5;	28 6				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	3 11;	9 14;	21 21;	29 0				

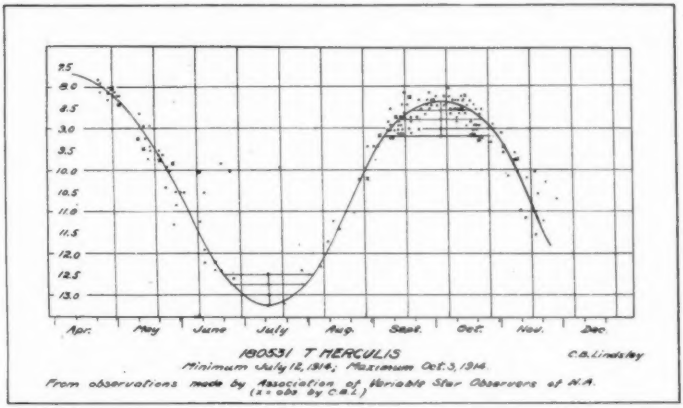
Maxima of Variable Stars of Short Period—Continued.

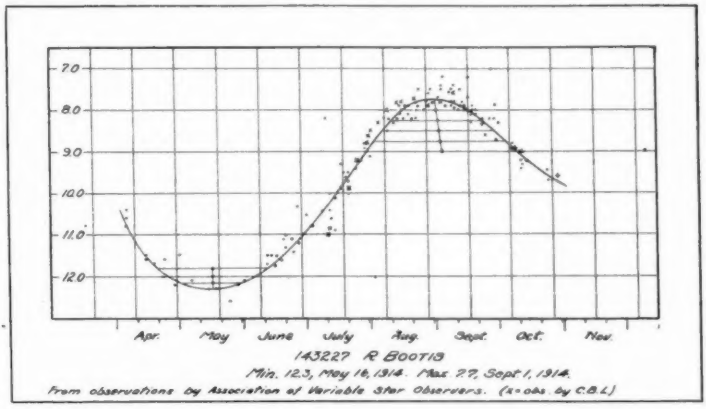
Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1915. April.							
	h m	° ′		d h	d	h	d	h	d	h	d	h
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	1	22;	7	21;	19	18;	25	17
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	5	10;	14	12;	23	15		
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	5	18;	12	19;	19	19;	26	20
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	7	8;	14	8;	21	8;	28	8
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	4	7;	12	6;	20	6;	28	5
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	6	6;	13	22;	21	15;	29	7
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	1	20;	9	1;	16	5;	23	9
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	6	4;	14	13;	22	22		
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	3	0;	10	7;	22	23;	29	6
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	7	10;	23	19				
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	3	22;	12	19;	21	16;	30	13
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	2	4;	8	21;	22	8;	29	2
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	2	5;	8	22;	15	15;	29	2
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	3	21;	18	15				
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	3	9;	11	5;	19	2;	26	23
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	7	19;	14	16;	21	14;	28	11
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	4	20;	14	13;	24	6;	29	3
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	3	15;	12	7;	20	22;	29	14
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	5	23;	11	8;	22	2;	27	10
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	9	1;	19	22;	30	19		
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	2	14;	9	0;	15	10;	28	6
V Lacertae	22 44.5	+55 48	8.2— 8.9	4 23.6	5	3;	15	2;	25	1;	30	1
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	1	1;	11	22;	17	9;	28	6
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	6	7;	12	15;	18	22;	25	5
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4			8	17;	20	21		
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	4	10;	14	10;	24	9;	29	9

Light Curves of Variable stars.—We are indebted to Mr. C. B. Lindsley for the following light curves of variable stars, constructed from observations by the members of the American Association of Variable Star Observers. Other curves will be printed in later numbers of POPULAR ASTRONOMY.




JAN. Max. 1, long Jan. 16
FEB.
Max. 2, Short? MAR.
APRIL
Max. 3, long May 1
JUNE
Max. 4, Short July 5
AUG.
Max. 5, long Aug. 14
SEPT.
Max. 6, Short Oct. 2
OCT.
Max. 7, Short NOV.
DEC. Max. 8, Dec. 27.
LIGHT CURVE for 1914 of 213843 SS CYGNI from OBSERVATIONS by ASSN. of VAR. STAR OBSERVERS of AMERICA.
C.B.L.





COMET AND ASTEROID NOTES.

New Comet 1915 *a* (Mellish).—The discovery of a new comet by Mr. John E. Mellish, of Cottage Grove, Wisconsin, was announced by telegram from Harvard College Observatory, February 10. The comet was then in the constellation Ophiuchus about five degrees west and a degree south of the star σ. It is moving very slowly eastward and a little southward. On March 1 it will be about two degrees almost due south of the star σ.

The weather has been very bad at Northfield so that we have observed the comet only once. On the morning of February 17 it was easily picked up with the 5-inch finder. With the 16-inch telescope it was perhaps 2′ in diameter, with a quite strong nuclear condensation, so that measures of its position were fairly accurate. The coma was oval in shape, the elongation being toward the northwest.

The following observations are all that have come to hand:

Greenwich Mean Time	R. A.	Decl.	Place	Observer
	h m s	° ′ ″		
1915 Feb. 13.0619	17 06 01.9	+2 59 01	Mt.Hamilton	Aitken
14.0486	07 17.5	+2 54 27	Mt.Hamilton	Aitken
15.5374	09 11.2	+2 47 43	Taschkent	.....
15.6309	11 19.4	+2 40 57	Bergedorf	.....
16.9862	11 01.6	+2 40 55	Northfield	Wilson
17.9111	17 12 12.2	+2 36 55	Washington	Burton

Elements of Comet 1915 *a* (Mellish).—A telegram received at this Observatory from Professor A. O. Leuschner, Director of the Students' Observatory, Berkeley, California, gives the following elements and ephemeris of Mellish's Comet, computed by Professor Crawford and Miss Young from observations on February 13, 14, and 16:—

ELEMENTS.

Time of perihelion passage	(T)	August 2.39 G.M.T.
Perihelion minus node	(ω)	225° 54′
Longitude of node	(Ω)	79 28
Inclination	(i)	48 37
Perihelion distance	(q)	1.495

EPHEMERIS.

G. M. T.	R. A.	Dec.	Light
	h m s	° ′	
1915 Feb. 21.5	17 16 44	+2 20	1.19
25.5	17 21 42	2 02	
Mar. 1.5	17 26 37	1 43	
5.5	17 31 28	+1 24	1.59

A cablegram from Copenhagen gives the following position of the comet from an observation made at Bergedorf:—

Feb. 15.6309 G. M. T. R. A. $17^h\ 11^m\ 19^s.4$ Decl. +2° 40′ 57″

EDWARD C. PICKERING,
Director.

Harvard College Observatory, Bulletin 577.
Cambridge, Mass., U.S.A., February 19, 1915.

Supposed Comet an Asteroid.—A telegram from Harvard College Observatory February 18 announced the discovery of Metcalf's Periodic comet (1906 IV) by Miss H. S. Leavitt upon photographs taken with the 16-inch Metcalf telescope The positions given were

G. M. T.	R. A.	Decl.
	h m s	° ′ ″
Feb. 9.683	8 28 36.2	−1 30 41
9.759	8 28 33.5	−1 30 19

A later telegram announces that the object is an asteroid.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Jan.-Feb., 1915.

Considering the inclement weather of the past month, the work of the Association has been most satisfactory, especially so in view of the fact that several of our best observers have been temporarily diverted from the work.

Signor G. B. Lacchini is to be congratulated on the publication of his observations of eleven long-period variables from 1911 to 1914. The pamphlet was published by the Royal Osservatorio Astronomico Di Capodimonte, Naples and is a great credit to its author.

Members will be gratified to learn that Dr. Gray's health is improving. We hope the time may soon come when the genial Doctor can join once more in the active work of the Association he has served so faithfully heretofore.

Messrs. Eaton and Mills have taken zones 14 and 10 respectively in the Nova search we have instituted in accordance with Mr. Leon Campbell's plan. Only a few zones remain unclaimed, and it is hoped that these will soon be taken in order that the entire area proposed for observation can be covered.

Thanks are due Messrs. Lindsley and Pickering for the many fine blue prints of the charts that they have so generously contributed for distribution. Mr. Lindsley deserves special mention for his carefully executed curve of the variable 213843 SS Cygni, the result of the work of the Association for the past year. Mr. Lindsley also drew an exceptionally good curve of 043274 X Camelop.

Mr. Richter continues to lead in the number of observations contributed. His list this month contained 380 observations.

Mr. Barbour also deserves credit for his list of 119 estimates, quite remarkable considering the few nights available for observing.

Attention is called to the discordance in the observations of 011272 S Cassiopeiæ. Here we find two observers recording a faint estimates of the 11.0 magnitude, and three observers in close agreement with estimate of the 9.0 magnitude. The "Companion to the Observatory" cites a calculated maximum for January 11. Will observers of this star please use special care in the matter of identification in order to reconcile the present lack of agreement.

During the month of January we observed the maximum of 093934 R Leo. Min. 123160 T Urs. Maj. and 142539 V Böotis, all in ascordance with calculated maxima of these variables. Our observations also indicate a maximum of 230110 R Pegasi December 3, 1914, magnitude 7.7. This date is 379 days from the last observed maximum November 19, 1913. The designated period is 377.5 days.

A meeting of the members of the Association is to be held in New York City at Easter time, and it is hoped that many will be able to attend. Members in attendance at the last meeting were unanimous in their expressions of the benefits to be derived by such gatherings, and that they should be made annual affairs. A good attendance at the coming meeting is very much desired.

The secretary has recently had letters of inquiry relative to the nature and scope of the work we are engaged in, from observers at Elmira College, Elmira, N.Y., Alabama Polytechnic Institute, Auburn, Ala., and Millsaps College, Jackson, Miss. These institutions are possessed of fine telescopes, and it is hoped that they may render our cause the good service it deserves.

Variable Star Observations Jan.-Feb. 1915.

001726
T Androm.

Mo.	Day	Est	Obs.
1	2	9.8	Bb
	4	9.8	Bu
	5	9.6	S
	5	9.6	Bb
	8	9.5	Bb
	9	9.4	R
	9	9.3	V
	10	9.1	R
	11	9.0	R
	12	9.4	Bb
	12	8.9	R
	12	9.0	Hy
	14	9.3	E
	15	9.2	Bb
	15	8.9	R
	17	8.8	R
	17	9.0	Hy
	18	8.8	R
	20	9.2	Bu
2	4	8.8	O
	9	8.8	O

001755
T Cassiop.

Mo.	Day	Est	Obs.
1	2	9.1	Bb
	2	9.2	R
	3	9.2	R
	4	9.3	Bu
	4	9.2	R
	5	8.7	S
	5	9.1	Bb
	6	9.3	R
	7	8.6	M
	7	9.3	R
	8	9.2	Bb
	9	9.3	R
	10	7.8	Sp
	10	9.3	R
	11	9.3	R
	12	9.3	Bb
	12	9.3	R
	13	8.1	B
	15	9.4	R
	15	9.3	Bb
	17	9.4	R
	18	9.4	R
	20	9.8	Bu
	20	9.4	Bb
	26	7.8	B

001838
R Androm.

Mo.	Day	Est	Obs.
1	5	12.0	Hu

001909
S Ceti

Mo.	Day	Est	Obs.
1	3	8.5	R
	4	8.0	Bu
	4	8.5	R
	6	8.5	R
	7	8.5	R
	9	8.4	R

S Ceti

Mo.	Day	Est	Obs.
1	10	8.4	R
	11	8.4	R
	12	8.4	R
	15	8.4	R
	17	8.5	R
	20	8.2	Bu

003179
Y Cephei

Mo.	Day	Est	Obs.
1	10	9.7	Hu

004047
U Cassiop.

Mo.	Day	Est	Obs.
1	4	10.5	Bu
	7	8.8	Y
	7	8.8	S
	13	8.6	B
	20	9.2	Bu
	26	8.5	B

004435
V Androm.

Mo.	Day	Est	Obs.
1	5	12.6	Hu
2	4	10.9	O

004533
RR Androm.

Mo.	Day	Est	Obs.
1	4	9.8	Bu
	5	10.0	Hu
	14	10.5	E
	20	10.6	Bu

004746
RV Cassiop.

Mo.	Day	Est	Obs.
1	2	8.7	Bb
	5	8.6	Bb

004958
W Cassiop.

Mo.	Day	Est	Obs.
1	7	11.0	Y
	10	10.8	Sp
	13	10.0	B
	21	10.1	Y
	26	9.5	B

010940
U Androm.

Mo.	Day	Est	Obs.
1	18	11.0	E

011272
S Cassiop.

Mo.	Day	Est	Obs.
1	1	11.1	M
	2	11.8	Bb
	4	9.3	R
	5	11.8	Bb
	6	9.3	R
	7	9.2	R
	9	9.1	Ma
	9	9.3	R
	10	9.3	R
	11	9.2	R
	12	9.1	R
	13	8.9	B

S Cassiop.

Mo.	Day	Est	Obs.
1	15	9.1	R
	17	9.1	R
	18	9.0	R
	26	7.9	B

011208
S Piscium

Mo.	Day	Est	Obs.
1	13	11.5	B
	18	12.0	E

011712
U Piscium

Mo.	Day	Est	Obs.
1	18	11.2	E

012502
R Piscium

Mo.	Day	Est	Obs.
1	3	9.1	R
	4	9.2	Bu
	4	9.0	R
	6	9.3	R
	7	8.9	R
	7	9.1	S
	9	9.0	R
	10	9.1	R
	11	9.2	R
	12	9.3	R
	12	9.2	Hy
	15	9.3	R
	17	9.3	R
	17	9.2	Hy
	18	9.5	E
	18	9.3	R
	20	9.8	Bu
2	4	10.2	Y

013338
Y Androm.

Mo.	Day	Est	Obs.
1	18	11.4	E

014958
X Cassiop.

Mo.	Day	Est	Obs.
1	1	10.1	M
	4	9.2	Bu
	13	9.5	B
	20	9.8	Bu
	26	9.5	B

015254
U Persei

Mo.	Day	Est	Obs.
1	1	8.4	M
	2	7.8	Bb
	4	7.5	Bu
	4	8.4	R
	5	7.8	Bb
	6	8.6	R
	7	8.9	R
	7	7.0	Hu
	8	7.6	Bb
	9	9.0	R
	9	8.5	V
	10	8.9	R
	11	9.0	R
	12	7.6	Bb

U Persei

Mo.	Day	Est	Obs.
1	12	8.8	R
	12	8.7	Hy
	15	8.9	R
	15	7.5	Bb
	17	9.0	R
	17	8.5	Hy
	18	8.9	R
	20	7.9	Bu

021024
R Arietis

Mo.	Day	Est	Obs.
1	13	10.0	Hu
	20	10.4	Bu
2	4	10.4	O
	9	10.3	O

021403
o Ceti

Mo.	Day	Est	Obs.
1	2	4.8	Bb
	3	4.4	R
	4	4.5	Bu
	4	4.5	R
	5	4.6	Bb
	5	4.6	Ly
	5	4.0	Hu
	5	4.7	Pi
	6	4.4	R
	7	4.2	Ma
	7	4.4	R
	8	5.0	Mu
	8	4.3	Bb
	9	4.0	R
	9	4.5	Ly
	9	4.3	O
	9	4.2	Ma
	10	4.8	Mu
	10	4.0	R
	10	4.3	O
	11	4.5	Mu
	11	3.9	R
	12	3.9	R
	12	4.2	Bb
	13	3.9	Hu
	13	4.5	Ly
	14	4.2	Mu
	15	4.1	Bb
	15	3.9	O
	15	4.0	Mu
	15	3.9	R
	16	4.0	Mu
	16	4.3	Ly
	17	3.8	R
	17	3.9	Mu
	18	4.2	Ly
	18	3.8	R
	18	4.0	E
	18	3.9	Mu

o Ceti

Mo.	Day	Est	Obs.
1	19	3.8	Mu
	20	3.9	Bb
	20	3.8	O
	20	4.2	Bu
	29	3.8	O
2	4	3.8	O
	9	3.9	O

021658
S Persei

Mo.	Day	Est	Obs.
1	4	9.0	Bu
	5	10.5	Ly
	6	10.9	R
	7	10.8	R
	7	10.5	Sp
	8	10.5	Sp
	9	11.0	R
	9	10.4	Sp
	9	10.4	Ly
	10	11.0	R
	10	10.3	Sp
	11	11.0	R
	12	10.8	R
	15	10.8	R
	17	10.8	R
	18	10.6	R
	20	8.6	Bu

022000
R Ceti

Mo.	Day	Est	Obs.
1	7	12.0	Y
2	4	9.0	Y

022150
RR Persei

Mo.	Day	Est	Obs.
1	7	13.5±	Y

022813
U Ceti

Mo.	Day	Est	Obs.
1	4	9.0	Bu
	9	9.0	Hy
	9	9.0	Ma
	9	9.1	O
	12	8.8	Hy
	13	8.7	B
	17	8.7	Hy
	17	8.6	R
	18	8.3	R
	20	8.5	Bu

023133
R Triang.

Mo.	Day	Est	Obs.
1	2	10.2	Bb
	4	10.2	Bu
	5	10.2	Bb
	7	10.3	B
	8	10.3	Bb
	12	10.4	Bb
	13	9.8	Hu
	15	10.4	Bb
	20	10.6	Bb
2	4	11.5	Y

VARIABLE STAR OBSERVATIONS Jan.-Feb., 1915—Continued.

024356
W Persei

Mo.	Day	Est.	Obs.
1	1	9.9	R
	2	10.4	R
	3	11.3	Hy
	3	10.4	R
	4	10.3	R
	5	10.7	Ly
	6	10.5	R
	7	10.5	R
	7	9.4	Hu
	9	9.4	Hy
	9	10.5	R
	10	10.4	R
	11	10.6	R
	12	9.2	Hy
	12	11.0	Bb
	12	10.4	R
	15	10.9	Bb
	15	10.4	R
	17	10.5	R
	17	9.3	Hy
	18	10.6	R
	20	11.1	Bb

030514
U Arietis

1	7	11.0	Y
2	4	8.9	Y

032043
Y Persei

1	1	9.3	R
	2	8.0	Bb
	2	9.4	R
	3	9.2	R
	4	8.0	Bu
	4	9.2	R
	5	7.9	Bb
	5	8.3	Ly
	6	9.2	R
	7	8.2	Hu
	7	9.1	R
	8	8.1	Bb
	9	8.5	Ma
	9	8.5	Hy
	9	9.1	R
	10	9.2	R
	12	8.1	Bb
	12	9.2	R
	12	8.5	Hy
	15	8.2	Bb
	15	9.1	R
	17	8.4	Hy
	17	9.2	R
	18	9.6	E
	18	9.2	R
	20	8.2	Bu
	20	8.4	Bb

032335
R Persei

Mo.	Day	Est.	Obs.
1	7	12.5	Y
	7	11.0	Hu
2	4	10.1	Y

033362
U Camelop.

1	2	8.6	R
	3	8.7	R
	4	8.7	R
	4	8.2	Bu
	6	8.7	R
	7	8.8	R
	9	8.7	R
	10	8.7	R
	11	8.8	R
	12	8.7	R
	15	8.7	R
	17	8.8	R
	18	8.7	R
	20	8.4	Bu

035915
V Eridani

1	5	8.5	Pi
	10	8.7	R
	12	8.6	Hy
	15	8.7	R
	17	8.7	R
	17	8.7	Hy
	18	8.7	R

042209
R Tauri

1	1	11.7	M
	4	13.6	B
	5	11.9	Hu

042215
W Tauri

1	1	11.4	M
	4	12.2	B
	5	11.5	M
	7	11.5	M
	9	11.6	M
	16	12.4	B

042309
S Tauri

1	5	11.2	Hu

043208
RX Tauri

1	2	9.8	Bb
	4	9.2	Bu
	4	9.1	B
	5	9.6	Bb
	5	9.5	Hu
	6	9.8	R
	7	9.6	R
	9	9.6	R
	9	9.1	O

RX Tauri

Mo.	Day	Est.	Obs.
1	10	9.8	R
	11	9.8	R
	12	9.9	R
	15	9.9	R
	16	9.7	B
	17	10.0	R
	18	10.3	R
	20	9.7	O
	20	8.9	Bu

043274
X Camelop.

1	2	8.8	Bb
	4	8.4	Bu
	5	8.5	Bb
	5	8.4	Pi
	7	8.2	Ly
	8	8.2	Bb
	8	8.2	Sp
	9	8.1	Sp
	9	8.0	O
	10	7.8	O
	10	7.8	Sp
	12	7.9	Bb
	13	8.1	Ly
	15	8.0	Bb
	20	8.1	Bu
	20	8.0	Bb
	20	7.5	O
	21	7.7	Sp
2	4	8.2	O
	9	8.2	O

044617
V Tauri

1	1	9.8	M
	4	9.6	B
	16	9.3	B
	20	9.2	Bu

045514
R Leporis

1	7	8.5	B
	7	8.5	Bu
	10	7.6	Sp
	20	8.9	Bu

050022
T Leporis

1	2	8.8	R
	3	8.8	R
	4	8.8	R
	6	8.9	R
	7	8.9	R
	9	8.5	Hy
	9	8.9	R
	10	9.0	R
	12	8.5	Hy
	12	8.9	R
	15	8.9	R
	17	8.5	Hy
	17	9.0	R
	18	8.9	R

050953
R Aurigae

Mo.	Day	Est.	Obs.
1	2	9.0	Bb
	3	9.1	R
	4	9.3	R
	5	8.8	Bb
	5	9.3	M
	6	9.2	R
	7	8.8	Bu
	7	9.3	R
	8	8.8	Bb
	9	9.2	R
	10	9.3	R
	11	9.3	R
	12	8.7	Bb
	12	9.3	R
	15	8.8	M
	15	8.7	Bb
	15	9.2	R
	17	9.3	R
	18	9.3	R
	20	8.6	Bu
	20	8.6	Bb
	22	8.5	Bb

052034
S Aurigæ

1	5	9.0	M
	15	9.0	M

052036
W Aurigae

1	3	11.1	R
	5	11.3	M
	6	11.1	R
	7	11.2	R
	9	11.2	R
	10	11.1	R
	10	11.0	O
	11	11.2	R
	12	11.3	R
	15	11.4	R
	17	11.1	R
	18	11.3	R

052404
S Orionis

1	5	10.0	M
	10	10.1	O

053005
T Orionis

1	5	9.8	Pi
	5	10.5	M
	7	10.6	M
	12	9.7	E
	13	10.3	Ly

054920
U Orionis

1	5	11.0	Hu
	5	11.0	Pi
	7	9.5	S

055353
Z Aurigae

Mo.	Day	Est.	Obs.
1	5	9.6	Pi
	9	95	Y

060124
S Leporis

1	15.6	6.7	R
	17.6	6.7	R
	18.6	6.7	R

060450
X Aurigae

1	7	9.2	Bu
	10	8.8	O
	14	8.7	V
	20	8.7	Bu

060547
SS Aurigae

1	8.4	10.9	Sp

063558
S Lyncis

1	10	12.6	Sp
2	4	10.6	Y

064030
X Gemin.

1	7	9.0	Bu
	9	9.1	O
	14	9.2	V
	20	8.8	O
	20	8.5	Bu

064922
Nova Gemin. 2

1	2	11.9	Bb
	5	11.9	Bb
	8	12.1	Bb
	12	12.0	Bb
	15	12.1	Bb
	20	12.0	Bb
	22	11.9	Bb
	28	12.2	Bb

065208
X Monoc.

1	6	7.8	R
	9	7.7	R
	10	7.8	R
	13	7.4	Hu
	15	7.8	R
	17	7.9	R
	18	7.8	R

065355
R Lyncis

1	9	9.7	Bu
	9	9.9	O
	10	10.0	Sp
2	4	8.9	Y

VARIABLE STAR OBSERVATIONS Jan.-Feb., 1915—Continued.

065820
ζ Gemin..

Mo.	Day	Est.	Obs.
1	4.6	4.3	R
	6.7	3.7	R
	7.7	3.8	R
	9.6	3.7	R
	10.6	3.9	R
	11.7	3.9	R
	12.6	3.9	R
	15.6	4.1	R
	17.6	3.8	R
	18.6	3.7	R

070122a
Gemin.

Mo.	Day	Est.	Obs.
1	2	9.3	Bb
	3	8.8	R
	4	9.3	R
	5	9.6	Bb
	5	9.5	Pi
	6	9.2	R
	7	9.8	M
	7	8.9	Hu
	8	9.7	Bb
	8	9.3	Sp
	9	9.8	O
	9	9.8	Bu
	9	9.5	R
	10	9.8	R
	12	9.9	Bb
	12	9.5	R
	13	9.9	Ly
	15	9.5	M
	15	9.6	R
	15	9.9	Bb
	16	9.8	B
	17	9.6	R
	18	9.7	R
	20	10.1	Bb
	22	10.3	Bb

070312
R Can. Min.

Mo.	Day	Est.	Obs.
1	9	9.6	Bu
2	4	10.5	O

071713
V Gemin.

Mo.	Day	Est.	Obs.
1	5	10.0	Pi
	14	10.8	V

072708
S Can. Min.

Mo.	Day	Est.	Obs.
	2	7.8	Bb
	2	7.3	R
	3	7.1	R
	4	7.0	R
	5	7.6	Bb
	5	7.2	M
	6	6.9	R
	7	7.1	M
	7	7.1	Ly
	7	7.6	Ma

S Can. Min.

Mo.	Day	Est.	Obs.
1	7	7.4	S
	8	7.5	Bb
	9	6.9	R
	9	7.4	Bu
	9	7.0	Ly
	10	7.1	R
	11	7.2	R
	12	7.1	R
	12	7.2	Bb
	14	7.3	Ma
	15	7.0	R
	15	7.0	Bb
	17	7.1	R
	18	7.1	R
	19	7.0	M
	20	7.6	Bu
	20	7.0	Bb
	20	7.0	B
	22	6.9	Bb
	25	7.3	M
	28	7.2	Bb
2	4	7.7	O
	9	7.6	O

072811
T Can. Min.

Mo.	Day	Est.	Obs.
1	14	9.7	V
	20	9.5	B

073508
U Can. Min.

Mo.	Day	Est.	Obs.
1	2	8.7	Bb
	7	8.7	M
	8	9.2	Bb
	9	8.8	Bu
	20	8.3	Bu
	20	9.8	Bb
	22	9.8	Bb
2	4	9.9	O

073703
S Gemin.

Mo.	Day	Est.	Obs.
1	7	11.9	M
	7	11.4	Hu
	12	11.7	E

074323
T Gemin.

Mo.	Day	Est.	Obs.
1	2	8.5	Bb
	5	8.7	Pi
	7	8.9	M
	7	8.9	Hu
	8	9.0	Bb
	9	9.1	O
	9	8.9	Bu
	13	8.8	Ly
	14	8.3	V
	20	9.1	O
2	4	8.9	O
	9	9.1	O

081112
R Cancri

Mo.	Day	Est.	Obs.
1	8	10.5	E

081617
V Cancri

Mo.	Day	Est.	Obs.
1	8	12.5	E

081733
T Lyncis

Mo.	Day	Est.	Obs.
1	7	8.8	M
	10	8.6	M

084803
S Hydrae

Mo.	Day	Est.	Obs.
1	8	11.5	E
	22	10.8	Sp

085008
T Hydrae

Mo.	Day	Est.	Obs.
1	8	8.9	E

093934
R Leo. Min.

Mo.	Day	Est.	Obs.
1	5	7.5	Ly
	7	7.8	S
	8	7.6	E
	10	7.6	M

094211
R Leonis

Mo.	Day	Est.	Obs.
1	7	6.4	S
	7	6.4	Sp
	8	6.6	E
	8	6.4	Sp
	9	6.3	Sp
	10	6.6	M
	19	6.0	R
	25	6.4	M

103212
U Hydrae

Mo.	Day	Est.	Obs.
1	19	6.4	R

103769
R Urs. Maj.

Mo.	Day	Est.	Obs.
1	2	10.8	Ly
	7	10.5	Ly
	7	11.1	M
	7	10.6	S
	7	10.4	Sp
	8	10.4	Sp
	9	10.5	Ly
	9	10.2	Sp
	10	10.8	M
	10	10.0	Sp
	13	9.8	Ly
	15	9.5	M
	17	9.0	M
	19	8.7	M
	20	8.1	B
	20	8.3	Sp
	22	8.2	Sp
	25	8.5	M
	29	8.2	M

115919
R Comae

Mo.	Day	Est.	Obs.
1	19	7.8	R

123160
T Urs. Maj.

Mo.	Day	Est.	Obs.
1	4	7.2	Bu
	7	7.2	M
	7	7.3	Bu
	7	7.6	Sp
	7	7.7	Ly
	7	7.7	S
	8	7.3	E
	8	7.6	Sp
	9	7.4	Bu
	9	7.4	Sp
	10	7.5	Sp
	10	7.1	M
	16	7.2	Ly
	17	7.4	M
	18	7.5	E
	19	7.7	M
	19	8.1	R
	20	7.6	Bu
	20	7.6	B
	22	7.8	Sp
	25	7.9	M
	29	8.0	M

123307
R Virginis

Mo.	Day	Est.	Obs.
1	22	11.0	Sp

123961
S Urs. Maj.

Mo.	Day	Est.	Obs.
1	4	9.8	Bu
	7	10.0	Bu
	7	9 6	Sp
	7	9.8	M
	7	9.8	Ly
	8	10.0	E
	8	9.7	Sp
	9	10.0	Bu
	9	9.8	Sp
	10	9.8	Sp
	10	10.0	M
	13	9.9	Ly
	17	10.5	M
	18	10.1	E
	19	10.5	R
	20	10.4	Bu
	20	10.6	B
	22	10.5	Sp

134440
R Can. Ven.

Mo.	Day	Est.	Obs.
1	2	9.1	Ly
	8	8.9	E
	10	8.9	M
	20	8.5	Bu
	25	8.6	M
	29	8.4	M

141567
U Urs. Min.

Mo.	Day	Est.	Obs.
1	9	8.9	Bu
	20	8.8	Bu

141954
S Boötis

Mo.	Day	Est.	Obs.
1	19	8.6	R

142539
V Boötis

Mo.	Day	Est.	Obs.
1	19	7.9	R
	22	7.5	Sp
	29	7.7	M

142584
R Camelop.

Mo.	Day	Est.	Obs.
1	7	8.6	B
	9	8.8	Bu
	10	8.7	O
	20	9.0	Bu
	20	9.2	O
2	4	10.1	O
	9	10.3	O

151731
S Cor. Bor.

Mo.	Day	Est.	Obs.
1	19	6.8	R
	22	7.0	Sp

153378
S Urs. Min.

Mo.	Day	Est.	Obs.
1	9	11.2	Sp
	10	11.3	Sp
	22	11.5	Sp

154428
R Cor. Bor.

Mo.	Day	Est.	Obs.
1	19.0	6.1	R

163172
R Urs. Min.

Mo.	Day	Est.	Obs.
1	20	9.3	Bu

163266
R Draconis

Mo.	Day	Est.	Obs.
1	3	8.1	R
	4	8.1	R
	5	7.7	Ly
	6	8.1	R
	9	8.3	R
	10	8.4	R
	12	8.5	R
	15	8.4	R
	17	8.5	R
	18	8.5	R
	20	8.0	Bu
	22	8.3	Sp

171333
u Herculis

Mo.	Day	Est.	Obs.
1	19	5.0	R

181136
W Lyrae

Mo.	Day	Est.	Obs.
1	19	8.3	R

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184633
β Lyrae

Mo.	Day	Est.	Obs.
1	2.6	3.8	R
	3.6	3.8	R
	4.6	3.7	R
	10.6	3.4	R
	12.6	3.7	R
	19.0	3.4	R

193449
R Cygni

Mo.	Day	Est.	Obs.
1	2	12.0	Bb
	20	11.7	Bb

193732
TT Cygni

Mo.	Day	Est.	Obs.
1	1	8.4	R
	2	8.0	Hy
	2	8.5	R
	3	8.4	R
	4	8.5	R
	9	8.2	R
	10	8.0	Hu
	10	8.3	R
	12	8.2	R
	15	8.2	R
	16	8.5	Ly
	18	8.2	R

194048
RT Cygni

Mo.	Day	Est.	Obs.
1	2	10.8	Bb
	2	10.1	R
	4	10.3	R
	5	10.8	Bb
	7	10.9	Bu
	7	11.0	M
	8	10.9	Bb
	10	10.9	Hu
	12	11.1	Bb

194632
χ Cygni

Mo.	Day	Est.	Obs.
1	1	5.3	R
	2	5.3	Bb
	2	5.3	R
	2	5.3	Ly
	3	5.4	R
	3	5.3	Hy
	4	5.3	R
	5	5.4	Bb
	6	5.4	R
	8	5.4	Bb
	9	5.5	R
	9	5.7	Ly
	10	5.6	Hu
	10	5.5	R
	12	5.5	R
	12	5.6	Bb
	15	5.6	Bb
	15	5.5	R
	17	5.5	R
	18	5.6	R

χ Cygni

Mo.	Day	Est.	Obs.
1	20	5.7	Bb
	22	5.6	Bb
	28	5.9	Bb

195116
S Sagittae

Mo.	Day	Est.	Obs.
1	2.5	5.6	Mu
	4.5	5.8	Mu
	8.5	6.0	Mu
	9.5	6.1	Mu

195849
Z Cygni

Mo.	Day	Est.	Obs.
1	7	12.4	B
	9	12.3	Y

200357
S Cygni

Mo.	Day	Est.	Obs.
1	7	12.7	B

200647
SV Cygni

Mo.	Day	Est.	Obs.
1	1	8.4	M
	1	9.6	R
	2	9.5	R
	3	9.4	R
	3	8.4	Hy
	4	9.4	R
	6	9.3	R
	7	9.0	Ly
	7	9.3	R
	9	8.4	Hy
	9	9.3	R
	10	8.0	Hu
	10	9.3	R
	12	8.5	Hy
	12	9.3	R
	15	9.4	R
	17	8.4	Hy
	17	9.3	R
	18	9.4	R

200715 b
RW Aquilae

Mo.	Day	Est.	Obs.
1	1	8.8	R
	2	9.1	R
	4	8.8	R
	9	9.2	R
	10	9.0	R
	12	8.7	R

200916
R Sagittae

Mo.	Day	Est.	Obs.
1	1	9.4	R
	4	9.6	R
	9	9.6	R
	10	9.5	R
	12	8.9	R

200938
RS Cygni

Mo.	Day	Est.	Obs.
1	1	7.4	R
	2	7.5	R
	3	7.5	R
	4	7.6	R
	6	7.7	R
	7	8.1	Ly
	9	7.8	R
	9	8.2	Ma
	10	7.5	R
	12	7.6	R
	15	8.2	M
	15	7.5	R
	17	7.7	R
	18	7.5	R

201647
U Cygni

Mo.	Day	Est.	Obs.
1	1	8.2	M
	1	7.8	R
	2	7.5	Bb
	2	8.0	R
	3	8.1	R
	4	8.1	R
	5	7.8	Ly
	5	7.5	Bb
	6	8.2	R
	7	7.7	Ly
	7	8.2	R
	8	7.6	Bb
	9	7.9	Ly
	9	8.3	R
	9	7.8	Hy
	10	8.2	R
	12	7.9	Hy
	12	7.8	Bb
	12	8.2	R
	15	7.9	Bb
	15	8.3	R
	17	8.7	Hy
	17	8.3	R
	18	8.3	R
	20	7.9	Bb
	22	8.0	Bb
	28	8.1	Bb

202539
RW Cygni

Mo.	Day	Est.	Obs.
1	1	8.9	M
	3	8.7	Hy
	7	8.6	Ly
	9	8.7	Hy
	12	8.7	Hy
	15	8.3	M
	17	8.7	Hy

202946
SZ Cygni

Mo.	Day	Est.	Obs.
1	1	9.9	R
	2	9.9	R
	3	9.1	R
	4	9.7	R

SZ Cygni

Mo.	Day	Est.	Obs.
1	6	9.6	R
	7	9.0	B
	7	9.2	R
	7	9.4	Ly
	9	9.6	R
	10	9.6	R
	10	8.3	Hu
	12	9.5	R
	15	9.8	R
	15	9.7	M
	17	9.9	R
	18	9.9	R

202954
ST Cygni

Mo.	Day	Est.	Obs.
1	7	11.4	B
	9	11.0	Y

203816
S Delphini

Mo.	Day	Est.	Obs.
1	9	11.0	Y

203847
V Cygni

Mo.	Day	Est.	Obs.
1	7	10.6	B

210868
T Cephei

Mo.	Day	Est.	Obs.
1	7	6.9	Ly
	7	6.8	M
	7	6.6	Ma
	9	7.1	Hy
	12	7.0	Hy
	13	7.1	Ly
	17	7.2	Hy
	20	7.0	O
2	4	8.2	O

213244
W Cygni

Mo.	Day	Est.	Obs.
1	1	6.4	R
	2	6.4	R
	3	6.4	R
	4	6.3	R
	6	6.3	R
	7	6.3	R
	9	6.3	R
	10	6.3	R
	11	6.3	R
	12	6.3	R
	15	6.2	R
	17	6.2	R
	18	6.2	R

213753
RU Cygni

Mo.	Day	Est.	Obs.
1	7	9.5	M
	16	9.5	Ly

213843
SS Cygni

Mo.	Day	Est.	Obs.
12	30.5	8.2	E
	31.5	8.3	E
1	1.6	7.9	R
	2.5	8.5	Ly
	2.6	8.1	R
	2.6	8.4	Hy
	2.7	8.2	Bb
	3.5	8.6	Hy
	3.6	8.2	R
	4.5	8.9	E
	4.6	8.0	R
	4.7	8.3	Bb
	5.5	8.7	Ly
	5.5	8.8	M
	5.5	8,8	S
	5.5	9.0	Hu
	5.7	8.3	Bb
	6.6	8.0	R
	6.7	8.4	Bb
	6.7	8.5	Bb
	7.5	9.0	M
	7.5	8.9	Ma
	7.5	9.5	Ly
	7.5	9.0	B
	9.5	9.3	S
	7.5	9.2	Hu
	7.6	8.2	R
	7.7	8.9	Bb
	7.8	9.2	Bb
	8.5	9.5	M
	8.5	9.3	E
	8.5	9.6	B
	8.7	9.5	Bb
	8.7	9.7	Bb
	9.4	10.1	O
	9.5	9.5	Hy
	9.5	10.2	Ly
	9.6	9.2	R
	9.6	9.8	M
	10.4	10.4	O
	10.4	10.6	Hu
	10.6	9.8	R
	11.6	10.4	R
	12.5	10.8	Hy
	12.6	11.2	R
	12.7	11.8	Bb
	13.5	11.7	Ly
	13.5	12.0	Hu
	13.6	11.9	B
	14.5	11.8	E
	15.5	11.8	M
	15.7	11.9	Bb
	16.5	11.9	B
	16.5	11.8	Ly
	17.6	11.5	R
	18.5	11.8	Ly
	18.5	11.8	E
	18.6	11.6	R

VARIABLE STAR OBSERVATIONS Jan.-Feb., 1915—Continued.

SS Cygni

Mo.	Day	Est.	Obs.
	20.5	12.0	B
	20.7	12.1	Bb
	22	12.1	Bb
	28	12.2	Bb

213937
RV Cygni

Mo.	Day	Est.	Obs.
1	2	8.0	R
	3	8.0	R
	4	8.0	R
	5	7.2	Hu
	6	7.9	R
	7	8.0	Ly
	7	7.9	M
	7	8.0	R
	8	7.4	Ma
	9	7.9	R
	10	7.9	R
	11	7.9	R
	12	7.9	R
	15	7.8	M
	17	8.0	R
	18	7.9	R

220613
Y Pegasi

Mo.	Day	Est.	Obs.
1	9	10.0	Y

220714
RS Pegasi

Mo.	Day	Est.	Obs.
1	9	10.5	Y

222439
S Lacertae

Mo.	Day	Est.	Obs.
1	7	8.4	Y

222557
δ Cephei

Mo.	Day	Est.	Obs.
1	1.6	4.3	R
	2.6	4.3	R
	3.6	4.2	R
	6.6	4.1	R
	7.6	4.2	R
	9.6	3.8	R
	10.6	4.0	R
	11.6	4.3	R
	12.6	4.1	R

δ Cephei

Mo.	Day	Est.	Obs.
1	15.6	3.9	R
	17.6	4.3	R
	18.6	4.3	R
	19.1	4.1	R

223841
R Lacertae

Mo.	Day	Est.	Obs.
1	7	9.7	Y

230110
R Pegasi

Mo.	Day	Est.	Obs.
1	2	8.8	R
	3	8.9	R
	4	9.0	R
	4	8.6	Bu
	5	8.5	Ly
	6	9.0	R
	7	9.0	R
	9	9.1	R
	9	8.7	Ma
	10	8.9	O
	10	9.1	R

R Pegasi

Mo.	Day	Est.	Obs.
1	11	9.2	R
	12	9.2	R
	12	7.8	Hy
	13	8.8	Ly
	15	9.2	R
	17	8.5	Hy
	17	9.3	R
	18	9.2	R
	20	8.9	Bu

230759
V Cassiop.

Mo.	Day	Est.	Obs.
1	10	9.9	Sp
	21	9.3	Y

233335
ST Androm.

Mo.	Day	Est.	Obs.
1	4	10.6	Bu
	5	10.6	Hu
	5	11.0	S
	13	10.5	Ly
	14	10.9	E

233815
R Aquarii

Mo.	Day	Est.	Obs.
1	3	10.0	R
	4	10.0	Bu
	4	10.0	R
	6	10.1	R
	9	10.1	R
	10	9.8	R
	12	9.9	R
	15	9.9	R
	17	9.9	R

235350
R Cassiop.

Mo.	Day	Est.	Obs.
1	13	8.4	B
	26	8.5	B

235525
Z Pegasi

Mo.	Day	Est.	Obs.
1	9	8.9	V
	21	9.0	Y

No. of observations 1001; No. of stars observed 122; No. of observers 17.

The following observers contributed to this report:

Messrs. Barbour, Bouton, Burbeck, Eaton, Hay, Hunter, Lindsley, Mach, McAteer, Mundt, Olcott, Pickering, Richter, Spinney, Vrooman, Miss Swartz, and Miss Young.

WILLIAM TYLER OLCOTT,
Corresponding Sec'y.

Norwich, Conn.
Feb. 10, 1915.

COMMUNICATIONS.

Date of the Picture "Reflections".—That picture "Reflections" in the last issue of POPULAR ASTRONOMY is one of the prettiest cuts that I have ever seen. It presented to me the observation that I made at that time so vividly that I looked it up in my diary.

I find that I made a drawing of the relative positions of the comet, Venus and the moon with the following note.

"1910 May 6, 4. A. M., I observed Halley's comet. The comet, Venus and the moon made almost a right angled triangle, with Venus at the vertex of the right angle. The comet was about 40° above the horizon, and the moon was a slender crescent about 2° above the horizon." I copy the drawing roughly that I made at that time. In the photograph Venus is on the right hand side of the line joining the comet and the moon, but I presume this was caused by the inversion of the lens. I am confident the correct date is 1910 May 6 near 4 A. M.

W. H. CASSELL.

Wytheville, Virginia.

The Date of the Picture "Reflections."—Replying to your inquiry whether any of your amateurs could identify the date by the relative position of Halley's comet, Venus and the crescent moon, as represented in the picture sent to you by Mr. C. M. Cooper, I judge the date to be May 6, 1910 between 3:30 and 4 a. m.

EDWIN FRANKENSTEIN.

97 Bruce Ave.
Yonkers, N. Y.

Mercury Visible in February.—I wish to report that I observed the planet Mercury 1915 February 4 6^h 30^m. It was plainly visible to the naked eye and was in close proximity to the planet Jupiter. This makes the fourth time that I have observed this planet at its eastern elongations that occur in February.

It is very seldom indeed, that Mercury can be seen with the naked eye at the elongations that occur other than during the month of February. At this observation it was easily first magnitude and was a few minutes in right ascension east of Jupiter and about 10° north of him in declination.

DR. WM. H. CASSELL.

Wytheville, Virginia.
1915 February 5.

A Nebular Hypothesis which will Solve the Mystery of the Glacial Period, with Geological and Astronomical Evidence.—In presenting a new theory of the nebular hypothesis, which will controvert the present accepted one, I am aware that I must present almost overwhelming evidence to succeed, because the scientific world is disposed to be conservative, and hold to a vague undefined theory, rather than change to a new one based only on speculative theoretical grounds.

When Sir Isaac Newton promulgated the law of gravity, we would expect his contemporaries to accept it immediately. Yet Science did not accept it for 50 years. Today this law requires no proof; it is self-evident, because it is old and part of our education. My theory is new and based on theory, which is not self-evident, but I propose to introduce evidence which will give more than theoretical value to my fundamental theory—latent heat.

In that article I tried to show that the law relating to latent heat in water applied to all vapors, that is, that the heat in water and steam was a chemical coefficient, in both the water and steam, and that the heat produced by combustion is due to the liberation of the latent heat of oxygen and hydrogen, that atmospheric air—oxygen and nitrogen—has been liquified by removing its latent heat, and that it remained a liquid till it evaporated from the absorption of heat from the atmosphere. Atmospheric, liquified air is produced by both pressure and utilizing the power an expanding gas has of absorbing heat from the gases under pressure. If this liquid air did not require heat to expand it, so as to restore its latent heat, it ought to expand the moment pressure was removed.

With this theory as a foundation I assume that in the world's nebula the vapors at the periphery would change from their gaseous form to their liquid one, and with gravity would tend towards the center of gravity, and moving with the velocity of circumference would accelerate the internal vapors.

If we now examine the Solar Nebula we will find this fact exemplified, and can point to the fact that any law which would apply to the Solar Nebula would apply to the world nebula.

	Sidereal period
Neptune	164 years
Uranus	84 "
Saturn	29 "
Jupiter	9 "
Mars	684 days
Earth	365 "
Venus	224 "
Mercury	88 "

This shows that there was progressive acceleration of velocity towards the sun with lessening of the sidereal periodicity. Let us see if we can account for this on a rational assumption. The four outer planets are so light in weight, that they show they have lost all their mineral and metal vapors by attraction of gravitation and were left so light that all of them would float in water. Mars is 1½ times the weight of granite while earth is twice as heavy.

The metals, being the first to respond to gravity, would be the first to reach the center. The fact that the moon has a density half that of the earth, and about that of granite, shows that the nebula extracted by gravity all the metals from the moon's zone, before the earth and moon separated. One face of the moon being presented to earth, and its not having any axis of its own on which it revolves, shows it was originally a part of the world nebula, and still revolves on its original axis, that of the world.

These minerals revolving around in the nebular vapors would increase the revolutions of the internal zones and when increased velocity and internal resistance found a balance, the earth's diurnal round was 24 hours, while the moon's period remained that of the nebula. The same phenomenon is shown in the solar nebula. The period of nebula was, the earliest at which we can make one, near that of Neptune while the velocity of each planet is increased progressively to sun. Now if we take up this question from the standpoint of geology I think we will find some striking evidence. When life and vegetation appeared during the coal period, according to the accepted theory that the earth contracted as a concrete whole, the earth had received all its material from the nebula. There is no other logical conclusion, yet we find that all the coal measures all over the world are buried under about 1000 feet of rock. Professor J. D. Dana, in his geological work, said that the earlier geologists were very much puzzled by these facts till Sir Chas. Lyell pointed out that this material came from higher up according to the phenomena of today, namely water and erosion. This observation of Lyell's is true when we confine our observation to a circumscribed area, but if we look over a wide scope of country like half the area of the United states, from the coast range to the mountains of Colorado, we will find that almost every state in that district has coal mines covered up by the average amount of superimposed rock and there is not a break in the carboniferous formation where a "higher up" can be located.

My theory locates the higher up in the nebula. After life and vegetation began there still remained nebular matter above and resting on our atmosphere enough nebular matter at close range to give energy to sustain animal and vegetable life, without day or night, or change of season, with a temperate climate from pole to pole. Rain fell, which shows there was change in temperature enough to produce rain.

The centrifugal force of earth would force a thicker blanket of nebular material over the equator, and the poles would be the first localities to get a clear sky. Then the glacial period would begin and it would end when the equator showed a clear sky

Nature's plan would be the same for all the planets. Saturn has its rings around the equator indicating that it is in a similar stage to that of our earth at the end of its glacial period.

I am indebted to Dr. Frederic Campbell, Sc. D., an amateur astronomer of Beaver Falls, N. Y., for the information that spectroscopic analysis of Saturn's rings indicates that they are composed of solid matter, probably dust, that is, nebular matter which has passed through its liquid to solid form *in situ* and is now furnishing that planet with a dust-like material similar to that our planet received during the Quartenary period.

Jupiter is in a like condition to earth during its pre-glacial period, having nebular matter surrounding this planet, so we cannot see the surface.

One of the arguments in favor of this theory, is based on the assumption, that all the vapors of the nebula had different meteorological points at which they liquified. Now if we examine the evidence given by the Solar Nebula, we will find sufficient confirmation to justify this assumption.

All the planets beyond Mars are composed of such solid material, of which we have no counterpart on the earth's crust, so that we have to guess what they are. All we can say with any degree of certainty, is they were gases that could not solidify on the earth on account of temperature. Therefore we are left to assume that these planets are composed of solid oxygen, nitrogen, hydrogen and other gases we know nothing of which become solid on account of the extreme cold, after the metals and minerals were filtered out of the Solar Nebula, according to law. We see this selective working of the world nebula, in that the metals were filtered out of the moon's zone. All the evidence points to the metals being the first to reach the center of gravity and displace the earlier ones and that the interior of the world is composed largely of metals, and the lighter minerals form the outer crust.

ALLAN P. MACDONALD, M. D.

Danbury, Conn.

GENERAL NOTES.

Dr. F. W. Dyson, astronomer royal of England, is among those who were knighted on New Year's day.

Professor Alfred Fowler, of the Royal College of Science, London, has been awarded the gold medal of the Royal Astronomical Society for his researches in stellar spectroscopy.

The Bruce Medal.—We have heard, through private letters, that the Astronomical Society of the Pacific has awarded the Bruce medal for 1915 to Dr. W. W. Campbell. The official presentation will be made in August when the Astronomical Society of America will be in session in California.

Mr. Carl Otto Lampland of the Lowell Observatory has been elected a member of the American Academy.

Dr. Frederick Campbell, who was formerly President of the Department of Astronomy in the Brooklyn Institute of Arts and Sciences, has removed from Brooklyn, N. Y., to Beaver Falls, N. Y. With the return of hitherto impaired health, Dr. Campbell has resumed public lecturing on the subject of Astronomy; he also continues writing for the Newark Evening News, and Boys' World, as well as occasionally for POPULAR ASTRONOMY and other periodicals.

Dr. William R. Brooks, director of the Smith Observatory, and professor of astronomy of Hobart College, lectured for Miss Alice O. Stickney's classes in astronomy at the high school at Lowell, Mass., on Monday evening, February 15, 1915. While the lecture was for the entertainment and instruction of the students, it was also open to the public and the school hall was filled with a large and very appreciative audience. Dr. Brooks' subject was "The Wonders of the Heavens or Other Worlds than Ours," and he treated it in a very interesting and instructive manner. Many interesting stereopticon views were shown to illustrate the work.

The Lowell High School is showing a commendable interest in astronomical matters. They are using an excellent 3½ inch portable equatorial telescope and have the opportunity of using occasionally a 5-inch instrument. They have recently purchased an expensive instrument for projecting either opaque pictures or stereopticon slides.

The Royal Astronomical Society has never admitted women to fellowship. The advisability of doing so is to be thoroughly debated at the annual meeting. It is not at all unlikely that the statutes will be changed to make this possible.

L'Astronomie, the French popular astronomical magazine, has just issued its September and October numbers which were delayed by the war. The November and December numbers will follow soon.

The Royal Observatory of Brussels.—From *L'Astronomie* we learn that the Royal Observatory at Uccle, near Brussels, Belgium, has escaped destruction. In August it was transformed into a hospital and the astronomers were utilized as Red Cross attendants.

The Gazette Astronomique.—The occupation of the city Anvers by the Germans interrupted the publication of the Belgian paper, *Gazette Astronomique.* A number of English on the initiative of Mrs. Fiammetta Wilson of Bexley Heath, have undertaken to re-establish the magazine, beginning with January 1, 1915. The subscription price is five shillings, but larger subscriptions are solicited in order to assist the unfortunate Belgians to revive their astronomical paper. Subscriptions and correspondence should be addressed to M. Félix de Roy, honorary secretary, 29 Stamford Street, London, S. E.

An Exhibit of the Work of the Lowell Observatory has been held at the Boston Public Library since January first, where it has attracted great interest and crowds for over a month.

New Section of the S. P. A.—Mr. Frederick C. Leonard informs us that a "Section for Construction of Astronomical Instruments" has been formed by the society of which he is president. This has been placed under the direction of Professor M. Thomas Fullan, of the Alabama Polytechnic Institute, Auburn, Ala. Its purpose is to aid amateurs and beginners in the construction of telescopes and accessories. Professor Fullan has had wide experience in this line [illegible] in fact, at present preparing a book which shall deal with the subject of telescope construction.

Variability of Mars.—Mr. H. E. Lau, of Hoersholm, during the last opposition of Mars, from March 4 to May 17, 1914, studied the variations in brightness of the planet. Comparing it with the stars Capella ($0^m.21$), Procyon ($0^m.48$), Pollux ($1^m.21$) and Regulus ($1^m.34$), he found the planet varied as much as two tenths of a magnitude, the period of variation being the period of rotation of the planet. The maximum of brightness occurred when Martian longitude 120° was on the central meridian and the minimum corresponded to longitude 300°.

The Forty-inch Reflector of the Lowell Observatory has been equipped and used occasionally for visual observations during the past year. The full aperture of this instrument shows the canals of Mars as fine direct geometric lines, thus corroborating the work of the smaller apertures. This should dispose of the erroneous idea that such large apertures do not disclose these remarkable features.

Observations of Uranus recently made at the Lowell Observatory have added materially to our knowledge of that planet. Its oblateness, which was conspicuous, has been carefully measured and its plane undoubtedly coincides with that in which the satellites move. Measures on the belts indicate that they lie parallel to the same plane. Lastly, the satellite Titania has shown variability in brightness.

Note on the International Latitude Service.—From a letter recently received from Dr. Albrecht of the International Geodetic Association at Potsdam, it is learned that notwithstanding the war, observations for variation of latitude will be continual during the year 1915 at all the stations except Gaithersburg, Md. The observation books from Japan, Dr. Albrecht says, have thus far been received regularly. There is an interruption in the receipt of the books from Tschardjui, but not in the series of observations.

It is gratifying to know that the warring nations can still coöperate to some extent at least in scientific work.

J. G. PORTER.

A Remarkable Fireball.—On February 4 at $10^h\ 12.5^m$ E. S. T. a very remarkable fireball was seen here by three members of the staff. It was so brilliant that it lit up the country quite as brightly as does the moon at quarter. Taking the mean of our estimates its path was about 40° long and it took three seconds to traverse it. At the end it burst into a large number of fragments, some red, some green in color. The original body was a decided green. As is usual, the point of its beginning was not so well observed as its vanishing point. However, its direction was fairly well observed, so, at any rate, it passed through the first point given even though it began a little beyond it. This point was $\alpha = 7^h\ 44^m$, $\delta = 0°.0$ and it burst at $\alpha = 6^h\ 48^m$, $\delta = -\ 34°.2$. No trail was noticed nor was any sound heard though carefully listened for during several minutes. Roughly speaking it probably burst some 50 miles south of this place. Any one who saw the meteor is requested to send as full an account as possible to the writer, that its real path may be computed.

CHARLES P. OLIVIER.

Leander McCormick Observatory.
Feb. 6, 1915.

The North Polar Sequence.—Volume 71, No. 3, of the *Annals of Harvard College Observatory* contains an extensive and very thorough study of the magnitudes of 96 stars near the north pole for 1900 by Miss Henrietta S. Leavitt. The basis of the study was 299 photographs taken with 13 different telescopes whose apertures vary from 0.5 inch to 60 inches. It was found that large errors are introduced by the effect of distance from the center of the plates and also, when there are successive exposures, by changes of focus and other conditions which modify the apparent brightness of the images. As the color equation was found to vary for different instruments, corrections were applied to stars known to be redder than others. The suggestion is made that the definition of the International System of Photographic Magnitudes be enlarged to read:

"Photographic magnitudes coincide with photometric magnitudes on the Harvard System for stars having the spectra of Class A0 between the magnitudes 5.5 and 6.5, and are fainter than the photometric magnitudes by 1.00 magnitude for stars having spectra of class K0 between the same limits."

The final table of the concluded magnitudes of Standard Polar Stars contains 46 stars of the adopted sequence ranging from magnitude 4.58 to magnitude 21.10. Twelve red stars form a fairly good sequence from 6.80 to 13.48. Thirty-eight supplemental stars have been added with magnitudes ranging from 2.69 to 21.14.

Two excellent photographic charts are appended which will enable the observer to readily identify the stars which are visible with his telescope.

Sunspot Photography at Kashmir.—At the December meeting of the Royal Astronomical Society Professor H. H. Turner spoke of a recent discovery by Mr. and Mrs. Evershed that the climate of Kashmir, India, is much more favorable for work on the sun than anything they have ever before experienced. Kashmir is on a high valley plateau surrounded by mountains, and it was found that beautiful definition of the sun's limb was obtained every hour of the day. On the other hand, at the mountain observatory Kodaikanal only the early hours of the morning are available for work on the sun, because convection currents set up on the side of the mountain impair the seeing.

The Eversheds found the same result in their work in selecting a site for the new Cawthron Observatory in New Zealand. In the valley plain at a height of 5000 ft. above sea-level, they found that the definition was good in all types of weather, and whatever the position of the sun, and that this was the case at every point in the valley which they tried. But on ascending the mountains the definition at once fell off, and at a height of 7009 ft. was not nearly so good as in the valley.

Stellar Movements and the Structure of the Universe, by A. S. Eddington, Plumian Professor of Astronomy, University of Cambridge, 266 pp. The MacMillan Company, New York, and London. Price $1.60 net.

This is a remarkably interesting book to those who are thinking upon the problem of the universe and much of it is written in simple language which the average reader can follow. The discussion is based upon the most recent and most accurate data concerning the spectra and motions, both proper and radial, of the stars and concerning their distribution in space as revealed by photography and by the recent determinations of stellar parallax by various methods. A chapter is devoted to the moving clusters in Taurus, Ursa Major and Perseus, another to the solar motion, two to the general "Star-Streams", including the "Three-Drift Hypothesis" and the "Ellipsoidal Hypothesis". Other chapters deal with phenomena

associated with spectral type, particularly the increase of velocity from Type A to Type M, counts of the stars in various selected regions of sky, statistical investigations, the Milky Way, star clusters and nebulæ, and finally the dynamics of the stellar system. In the last chapter Eddington shows that the kinetic theory of gases cannot be applied to the stellar system. The motions of the stars are not analogous to the motions of molecules in a gas since collisions are so infrequent as to be negligible. The stars therefore "describe paths under the general attraction of the stellar system without interfering with one another." He asks a number of interesting questions to which there are not at present satisfactory answers. "Why have the stars in the early stages very small velocities. "Why do these velocities afterward increase? In particular how do the stars acquire velocities perpendicular to the original plane of distribution, which cause the latest types to be distributed in a nearly spherical form? How are the two star-streams to be explained? What is the meaning of the third stream, Drift O? Can the partial conforming to Maxwell's law be accounted for? What prevents the collapse of the Milky Way?"

Actual Time of Signals from the U.S. Naval Observatory, January, 1915.

Day	Time of signals Noon		Time of signals 10:00 p.m.	
	h m s		h m s	
1	11 59 59.98	−.02	9 59 59.96	−.04 Holiday
2	11 59 59.96	−.04	10 0 0.00	.00
3	12 0 0.01	+.01	10 0 0.00	.00 Sunday
4	12 0 0.01	+.01	10 0 0.02	+.02
5	12 0 0.02	+.02	10 0 0.01	+.01
6	12 0 0.13	+.13	9 59 59.99	−.01
7	12 0 0.01	+.01	9 59 59.97	−.03
8	12 0 0.00	.00	9 59 59.95	−.05
9	11 59 59.98	−.02	9 59 59.83	−.17
10	11 59 59.99	−.01	9 59 59.97	−.03 Sunday
11	11 59 59.98	−.02	9 59 59.94	−.06
12	11 59 59.95	−.05	9 59 59.96	−.04
13	11 59 59.95	−.05	9 59 59.98	−.02
14	11 59 59.94	−.06	9 59 59.93	−.07
15	11 59 59.95	−.05	10 0 0.02	+.02
16	12 0 0.03	+.03	10 0 0.04	+.04
17	12 0 0.04	+.04	10 0 0.04	+.04 Sunday
18	12 0 0.06	+.06	10 0 0.06	+.06
19	12 0 0.06	+.06	10 0 0.08	+.08
20	12 0 0.09	+.09	9 59 59.99	−.01
21	11 59 59.99	−.01	9 59 59.98	−.02
22	11 59 59.95	−.05	9 59 59.97	−.03
23	11 59 59.97	−.03	9 59 59.94	−.06
24	11 59 59.98	−.02	9 59 59.97	−.03 Sunday
25	11 59 59.96	−.04	9 59 59.95	−.05
26	11 59 59.95	−.05	10 0 0.02	+.02
27	12 0 0.03	+.03	10 0 0.05	+.05
28	12 0 0.05	+.05	10 0 0.06	+.06
29	12 0 0.07	+.07	10 0 0.07	+.07
30	12 0 0.08	+.08	9 59 59.99	−.01
31	11 59 59.99	−.01	9 59 59.97	−.03 Sunday

(+) slow (−) fast

Maximum error: Dec. 18, +.24.

U. S. Naval Observatory,
Washington, D. C.
Feburary 6, 1915.

J. A. Hoogewerff,
Captain U. S. Navy
Superintendent.

Sun Lore of all Ages.—Following his book "Star Lore of all Ages", Mr William Tyler Olcott has written a similar book on "Sun Lore of all Ages." It is a book of 327 pages and a complete index. It is handsomely bound, well printed and beautifully illustrated. The sun, because of the obvious dependence of all life upon the earth upon it, has become surrounded by a vast body of myth, legend and worship contributed to by practically every primitive people. There is no other natural object or phenomenon which has so generally occupied the minds of the untutored races all over the earth as the sun has. In this book Mr. Olcott has collected all this material from widely different sources and presented it in a clear, direct and interesting way. It is somewhat surprising to note that to a large extent the fundamental myths are much the same even though they come from extreme parts of the earth. Many ancient myths especially some among the Greeks are given new meaning and intelligible interpretation by relating them to the sun, as pointed out in this book. Any one, not necessarily an astronomer, who is interested in the traditions and early thought life of primitive peoples will find this book extremely valuable and suggestive. The author ends the book with a brief review of modern solar research. This of course sets forth facts that are now known in striking contrast with the vague superstitions and fears held by the early races before the days of accurate science.

The book is published by G. P. Putnam's Son's, New York City, Price $2.50.

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